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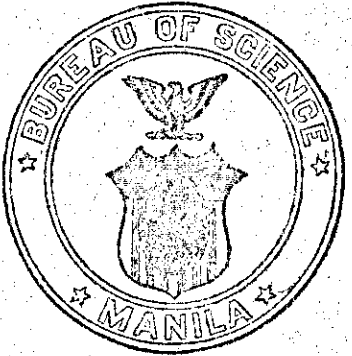

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THE PHILIPPINE
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VOL. XIV JUNE, 1919 No. 6

THE MECHANICAL PROPERTIES OF PHILIPPINE BAST-FIBER ROPES[1]

By ALBERT E. W. KING

(From the Division of General, Inorganic, and Physical Chemistry, Bureau of Science, Manila)

FIVE PLATES AND TWO TEXT FIGURES

There are numerous uncultivated species of plants in the Philippine Islands, for the most part belonging to the families Sterculiaceae, Tiliaceae, Malvaceae, and Moraceae, that form an interesting group in the fiber series. The fibers produced by these plants, which range from large trees to small weedlike shrubs, are derived from the tough bast that is found in the inner portion of the bark of the stems and of the branches. At present these fibers, with perhaps the exception of the fiber obtained from *Abroma fastuosa,* have no commercial significance in the Philippines; but in the rural districts they constitute a cheap material for the manufacture of cordage that is sufficiently resistant and durable for agricultural and animal-husbandry purposes.

Abacá (Manila hemp), which is the strongest and most resilient of all cordage fibers, is one of the most valuable export products of the Philippine Islands. However, it is not grown generally throughout the Archipelago, and its cultivation is restricted to certain favorable districts where there are fertile, well-drained soil, freedom from winds, and an abundant rainfall uniformly distributed throughout the year. Abacá is an expensive fiber, and it is natural that the districts in which it is not grown use the numerous local bast fibers rather than import Manila hemp, especially when transportation is difficult.

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[1] Received for publication January 24, 1919.

Therefore, in nearly all parts of the Philippines, outside of the abacá districts, the manufacture of cordage from the numerous bast fibers has developed into a common household industry.

Lamson-Scribner[2] has published a list of Philippine fiber plants comprising about one hundred seventeen species, among which are included many that yield basts. He gives their scientific and local names, with brief information regarding their distribution, the parts utilized, and their uses. Gilmore[3] also has given a list of some of the fibrous plants of the Philippines; he enumerates fifty-three species, some of which give basts, and gives their scientific and native names, occurrence, and their uses. Muller[4] devotes a chapter to fifteen of the most commonly used Philippine bast fibers and pays particular attention to the botanical descriptions and the distribution of the species. In three cases a description of the method of preparation of the fiber is included, but no data concerning the relative strengths of the basts are given.

Mendiola[5] has made a microscopical study of the ultimate fibers of thirteen Philippine bast-fiber plants. He also gives data on the tensile strength of "untwisted fibers and of cords," but their interpretation is difficult and is not at all clear. It would not be easy for another investigator to repeat the tests. No information is given as to the approximate size of the cords studied, their weight per unit length, their elongation, or the manner of testing; and "breaking load" is misnamed "breaking strain."

The present investigation was primarily undertaken for the purpose of securing quantitative results on the mechanical properties of bast ropes. A few short specimens of rope made of crude fiber already on hand, sufficient for about six tests each, were secured by me during a trip to the Ilocos Provinces and Abra in May, 1916, but most of the specimens were ordered in Abra and Benguet during November, 1916. In the household industry Filipinos mix the fibers from various species. There is little commercial demand for bast, so that in order to obtain specimens (and especially of a single species) these had to be made to order. Thirty-eight coils of rope were secured from material authentically identified in the Bureau of Science.[6] The ropes arrived at the Bureau of Science in March, 1917. By October of the same year, before there had been any insect infestation, the laboratory work in connection with this investigation had been completed. The length of the rope constituting a coil varied from about 25 to 60 meters. Thirty-two of the fibers used in fabricating the ropes tested were obtained from bast-plant species, and seven proved to be from species which gave nonbast fibers. In addition ropes from two standard cordage fibers, namely abacá and maguey, were used for the purpose of comparison. The species from which the fibers of the ropes tested were obtained are as follows:

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[2] Lamson-Scribner, F., List of Philippine Agricultural Products and Fiber Plants, *Bull. P. I. Bur. Agr.* ed. 2, 5 (1904) 36–47.

[3] Gilmore, J. W., Preliminary Report on the Commercial Fibers of the Philippine Islands, *P. I. Bur. Agr. Farmers' Bull.* 4 (1903).

[4] Muller, T., Industrial Fiber Plants of the Philippines, *Bull. P. I. Bur. Ed.* 49 (1913) 116–123.

[5] Philip. Agr. and Forester 6 (1917) 6–38.

SPECIES GIVING BASTS

STERCULIACEAE

Abroma fastuosa Jack.
Commersonia bartramia (Linn.) Merr.
Helicteres hirsuta Lour.
Kleinhovia hospita Linn.
Pterocymbium tinctorium (Blanco) Merr.
Pterospermum diversifolium Blume.
Sterculia crassiramea Merr.
Sterculia foetida Linn.
Sterculia oblongata R. Br.
Sterculia stipularis R. Br.

MALVACEAE

Bombycidendron vidalianum Merr. & Rolfe.
Malachra fasciata Jack.
Sida acuta Burm.
Thespesia lampas (Cav.) Dalz. & Gib.
Urena lobata Linn.

TILIACEAE

Columbia blancoi Rolfe.
Corchorus olitorius Linn.
Grewia bilamellata Gagnep.
Grewia eriocarpa Juss.
Grewia multiflora Juss.

MORACEAE

Allaeanthus glaber Warb.
Artocarpus communis Forst.
Ficus benjamina Linn.
Ficus forstenii Miq.
Ficus pachyphylla Merr.
Ficus palawanensis Merr.

BORAGINACEAE

Cordia cumingiana Vidal.
Cordia myxa Linn.

GNETACEAE

Gnetum sp.

BOMBACACEAE

Bombax ceiba Linn.

ULMACEAE

Trema orientalis Blume.

ANNONACEAE

Goniothalamus amuyon (Blanco) Merr.

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[6] All botanical work in connection with this investigation, such as naming and identifying species, was done by E. D. Merrill, chief of the botanical section of the Bureau of Science, who also furnished the information regarding the habitat, etc., of the plants.

SPECIES GIVING NONBAST FIBER

GRAMINEAE

Dendrocalamus merrillianus Elm.

MENISPERMACEAE

Anamirta cocculus W. & A.

PALMAE

Cocos nucifera Linn.
Corypha elata Roxb.

ZINGIBERACEAE

Amomum sp.

SPECIES GIVING STANDARD CORDAGE FIBER

AMARYLLIDACEAE

Agave cantala Perrine.

MUSACEAE

Musa textilis Née.

Incidental to obtaining bast ropes for testing their physical properties, observations were made on the methods employed in extracting bast and its manipulation during the process of fabrication into cordage. The process of preparation varies in detail of technic, depending upon the locality, the kind of fiber, its age, and the quality of cordage desired. The procedure in the Ilocos Provinces may be conveniently divided into (1) the plain stripping process, and (2) the water-retting process; the two methods yield very different products.

(1) The plain stripping process is much simpler, and requires less time, than the other method, and gives a rough, crude product. The bark is stripped from the main trunk or branches of the tree; generally the branches are cut off for convenience in peeling. Herbaceous or semiherbaceous plants are usually cut down entirely or pulled up by the roots, and the trimmed twigs or branches stripped of their bark. At certain times of the year, particularly after the rainy season when the tree is full of sap, it is an easy matter to strip the bark. The bark at one end of the branch or twig is loosened by beating with the flat side of a bolo and then stripped off. Generally the bast or inner bark is attached to the outer bark, although sometimes it is removed after the outer bark has been peeled off. When they come off together the two are separated by a subsequent operation, the outer bark is rejected, and the inner dried in the sun. The bast is then torn into narrow ribbons which, without any other preparation, are first spun into strands and then laid into rope. The ropes are bulky, rough, and lacking in flexibility, due to the high percentage of woody tissue, but are generally good enough for ordinary purposes. All of the ropes made to order, except two, were fabricated of crude bast obtained by this process.

(2) The water-retting process is usually practiced on the fibers obtained from herbaceous plants. The twigs and branches or

the crude fiber strips are immersed in water for ten to fourteen days until the pulp in which the basts are embedded is sufficiently decomposed. The extraneous matter is then removed by various manipulations, such as kneading, beating, wringing, and washing in water. Ultimately the bast is disencumbered of most of the plant tissue which contains gums, resins, sugars, and starches, and which do not add to the strength of the filaments but, instead, shorten the life of the fiber by attracting insects and fungi. The product is a filamentous bast which has an aspect altogether different from the crude strips obtained by the former process and is a much better cordage material. The fiber is dried in the sun and is spun into strands and eventually laid into ropes, as in the former process. Only two of the ropes tested were made of water-retted fiber, which makes a strong, neat, smooth, and flexible rope.

FABRICATION OF ROPE

The bast in the form of narrow strips, ribbons, or filaments is spun manually (usually without the aid of any mechanical device) into a continuous strand, having a more or less circular section, and is wound on a simple reel. Generally speaking, it would be more correct to name this first combination of fibers a yarn, but in this case the yarn is at the same time the strand. The size of the strand is determined by the ultimate diameter desired for the rope. This procedure of making the strand is partly made necessary by the bulky, inflexible nature of the bast strips, which do not lend themselves to the process of small-yarn spinning as do fine filamentous fibers such as cotton, abacá, or maguey. Furthermore, simplicity requires that the same method of having one thick yarn per strand be used with the retted filaments.

Having decided upon the length of the rope, as many lengths of spun fiber are cut from the supply on the reel as there are to be strands in the rope, and of a length longer than the finished rope, in order to allow for the shrinkage incurred by the twisting of the laying process. Nearly all of the bast ropes used in the Philippines are laid with three strands; one of those tested had two strands.

In the process of making a three-strand rope the three strands cut from the reel are tied at one end to three hardwood cranks or twirlers, which are mounted between two upright posts, and yoked so that they can be revolved simultaneously. This is the forward laying apparatus and is fixed. Its details are clearly shown in Plate II, fig. 1. The strands are now stretched horizontally to their full length and the three free ends are united and jointly fastened to a single crank that turns in a vertical wooden pillar which is mortised in a sliding shoe resting on the ground. This is the rear laying appliance, details of which are shown in Plate I, fig. 1. In some localities the shoe is fitted with a wooden wheel, or caster, to facilitate its movement over the ground, while in others the wheel is lacking and the shoe with its upright is simply dragged.

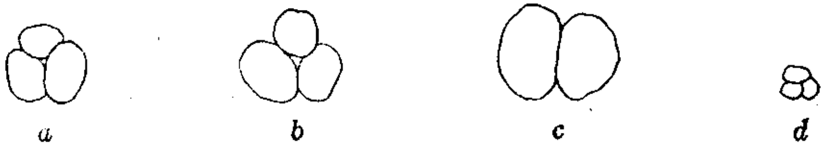

FIG. 1. Typical cross-sectional profiles of ropes tested. Actual size. *a*, rope made of *Cordia cumingiana* bast; *b*, rope made of *Kleinhovia hospita* bast; *c*, rope made of split bamboo (*Dendrocalamus merrillianus*); *d*, rope made of "F" grade abacá (machine laid).

After inserting a cylindrical block of wood with three grooves or flutes parallel to the long axis of the cylinder and at an angle of 120 degrees to each other, between the three strands just ahead of their point of juncture to the single twirler of the rear laying device, the strands are ready to be laid into rope. One man operates the three cranks of the forward laying device while another turns the single twirler at the rear in the opposite direction in order to give the rope the necessary twist. Meantime a third operator advances the grooved wooden block sufficiently slowly so that the strands may be twisted into a tight rope. Such a block is shown in place in Plate I, fig. 2. The twisting is continued until the grooved block is advanced to the three twirlers of the forward laying machine, at which point the operation is completed, and the rope is removed and coiled ready for use.

MECHANICAL TESTS OF BAST ROPE

Circumference and diameter.—The size of ordinary vegetable-fiber cordage of three or more strands is usually designated by its so-called circumference, which is actually its girth or perimeter. The girth of the test specimens was obtained by encompassing the rope with a strip of tough paper about two millimeters wide, and marking it at any convenient overlapping point. The paper was then straightened and the girth between the two marks measured. Due to the rough and nonuniform nature of the bast cordage the girth was not measured to fractions of a millimeter, but only to the nearest whole millimeter, which was sufficiently accurate for the purposes of this investigation. Each test specimen was measured close to each splice and in the middle, and the average of the three values used.

Diameters are not usually given in rope-test data. Direct diameter measurements would be very much more uncertain than girth measurements, especially if taken by inexperienced workmen, on account of the judgment required. To obtain such measurements numerous trials with the caliper must be made, and special care exercised to secure two diametrically opposite points, both in the boundary line of the strand and in the circumference of the circumscribing circle. The so-called "diameter" of the test specimens given in this paper was not measured directly and is not the true diameter, but was calculated upon the assumption that the girth measurement of the rope is a true circle. The relation of the girth to the true circumference and the relation of the so-called "diameter" to the actual diameter are discussed in a former paper.[7]

Actually, the diameter so calculated is a little less than the diameter of the circumscribing circle, but the difference is slight and the value is probably more accurate than could be obtained by direct measurement.

Cross-sectional areas.—Even with the most carefully machine-laid cordage, cross-sectional areas and values based on them are ambiguous unless accompanied by adequate explanations, and such data are very infrequently given in practice. The peculiarities of two- and three-strand cordage, shown in text fig. 1, more marked in the bast rope tested than in abacá or other filamentous fiber ropes, that make difficult the measurements of the actual solid, sectional area, are (1) the irregular trefoil shape of the rope section and (2) the appreciable void space in the strands themselves. The actual area contained within the three separate strands is much less than the area of a circumscribing circle, and the relation between the two is discussed in a previous paper.[8] There is an approximately constant ratio between these two factors, as is shown in Table I. In all of the tables in this paper the actual measurements of average girth were made in millimeters, of weight per meter in kilograms, and of breaking load in pounds, and the equivalents recorded are in round numbers, accurate to a fraction of a per cent.

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[7] King, A. E. W., Philip. Journ. Sci. § A 13 (1918) 285–339.

[8] King, loc. cit.

The results in Table I show that the true sectional area of the ropes tested varies from 62 to 100 per cent of the calculated area, the mean being 86 per cent. For small ropes, this mean percentage of the calculated area will give a fairly accurate approximation of the true sectional area.

TABLE I.—*Relationship between the mean calculated and the true mean area of the ropes tested.*

ROPES MADE OF BAST FIBERS.

Fiber.	Calculated area.	True mean area.	True mean area : calculated area.
	sq. mm.	*sq. mm.*	
Abroma fastuosa; rope made of crude bast strips	103.9	88.4	0.85
Abroma fastuosa; rope made of retted bast	28.7	24.4	0.85
Commersonia bartramia	115.0	97.5	0.85
Helicteres hirsuta	97.3	78.6	0.81
Kleinhovia hospita	120.8	116.6	0.96
Pterocymbium tinctorium	140.7	114.0	0.81
Pterospermum diversifolium	35.1	28.8	0.82
Sterculia crassiramea	126.7	121.3	0.96
Sterculia foetida	38.5	28.4	0.73
Sterculia oblongata	115.0	96.0	0.83
Sterculia stipularis forma	38.5	29.5	0.76
Bombycidendron vidalianum	38.5	31.6	0.82
Malachra fasciata	23.1	21.2	0.92
Sida acuta	45.8	40.8	0.89
Thespesia lampas	71.6	57.8	0.81
Urena lobata	35.1	30.3	0.87
Columbia blancoi	147.4	115.2	0.78
Corchorus olitorius	38.5	32.8	0.85
Grewia eriocarpa	31.9	25.9	0.82
Grewia multiflora	45.8	38.8	0.85
Grewia bilamellata	103.9	85.4	0.82
Allaeanthus glaber	120.8	100.2	0.83
Artocarpus communis	28.7	28.4	0.99
Ficus benjamina	42.0	32.5	0.77
Ficus forstenii	38.5	38.8	1.00
Ficus pachyphylla	38.5	32.3	0.84
Ficus palawanensis	28.7	20.5	0.72
Cordia cumingiana	115.0	86.8	0.76
Cordia myxa	49.7	44.5	0.90
Gnetum sp.	25.5	21.5	0.84
Bombax ceiba	54.1	43.0	0.80
Trema orientalis	54.1	46.6	0.86
Goniothalamus amuyon	66.5	40.9	0.62
Average			0.84

TABLE I.—*Relationship between the mean calculated and the true mean area of the ropes tested*—Continued.

ROPES MADE OF MISCELLANEOUS FIBERS.

Fiber.	Calculated area.	True mean area.	True mean area ÷ calculated area.
	sq. mm.	*sq. mm.*	
Musa textilis; grade "F" fiber [a]	76.5	76.9	1.00
Do	18.0	15.5	0.86
Musa textilis; grade "G" fiber [a]	54.1	53.5	0.99
Do	20.4	14.1	0.69
Agave cantala; Cebu No. 2, maguey [a]	54.1	43.6	0.81
Cocos nucifera; salt-water retted, from Caoayan, Ilocos Sur	198.6	159.8	0.80
Cocos nucifera; machine cleaned, from Laguna husks	153.9	131.0	0.85
Do	45.8	38.9	0.85
Corypha elata; leaf	174.4	173.7	0.99
Corypha elata; vascular fibers from petioles; buntal	38.5	34.7	0.90
Amomum sp	31.9	25.7	0.79
Dendrocalamus merrillianus [b]	168.6	159.5	0.94
Anamirta cocculus; entire stem of vine twisted into three-strand rope	153.9	128.7	0.84
Average			0.87

[a] Machine-made rope, the test specimens of which were kindly furnished by Johnson-Pickett Rope Company, of Manila; all other ropes are handmade.

[b] Two-strand rope; all other ropes have three strands.

Twist and girth.—The maximum tensile strength of fibers is obtained when they are tested in their untwisted condition, but it is not practicable to make a long rope except by overlapping and twisting the fibers so that they are held in place by mutual friction. Short ropes without any twist were tested by Duhamel[9] over one hundred years ago. He found such ropes to be much stronger and more pliable than twisted ones, but less durable because the rope opened when bent, thereby allowing free entry of water into the interior where the fibers were soon decomposed. Hooke,[10] as far back as 1669, gives data showing the diminished strength of twisted fiber. Experiments performed by Réaumur[11] show that vegetable fibers lose anywhere from 14 to 39 per cent of their original strength after being twisted into rope. Investigations made by Duhamel[12] at the time he was Minister of the French Marine show that the more tightly a rope was twisted the lower was its tensile strength. Rope that was comparatively loosely twisted was more pliable, less liable to run into kinks, and at least 25 per cent stronger than rope more tightly twisted.

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[9] Duhamel-Dumonceau, Henri-Louis, cited by Forbes Royle, page 20, data evidently taken from Traité de la Fabrique des Manoeuvres pour les Vaisseaux, ou l'Art de la Corderie perfectionée. Paris (1747).

[10] Cited by Royle, page 22.

[11] Quoted by Royle, page 22.

[12] Op. cit. 23. Royle gives the detailed results of several of Duhamel's experiments.

The more tightly the fiber is twisted in making a rope, the harder and more rigid will the rope become. Excessive twisting is injurious, and the fiber may be so tightly twisted that it is stressed very nearly to the point of rupture, in consequence of which the rope is unable to bear much load. The twist that different fibers will stand without losing too much of their original strength varies with the material.

The twist in all the ropes tested, or the length of one complete turn of a strand, was measured by placing a scale parallel to the longitudinal axis of the rope. In fig. 2 the distance *T* is considered the length of the twist. The values given in Table II are the means of five measurements, and show the relationship between the twist and the girth of the ropes tested. Fractions of a millimeter less than 0.5 have been dropped and those 0.5 or more have been counted as 1 millimeter.

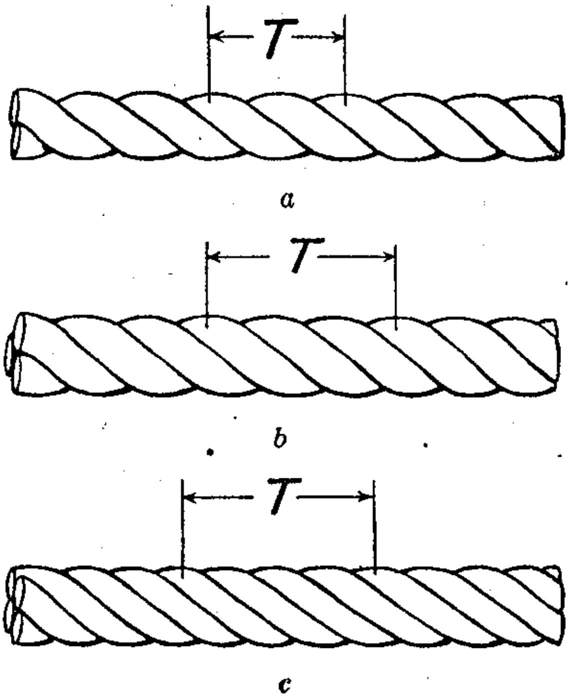

FIG. 2. Showing the twist of two-, three-, and four-strand ropes, respectively.

The results show that in ordinary rope, whether hand- or machine-made, the degree of twist is remarkably uniform. In a few cases the strand makes one turn in a distance equal to the girth of the rope, but as a whole the rope is laid more tightly and averages 87 per cent of the girth.

Testing machine for determining elongation and tensile strength.—An automatic, four-screw, universal testing machine having a capacity of 30,000 pounds and direct driven by a 1 horse power electric motor was used for breaking the more

TABLE II.—*Twist of the ropes tested and the relationship of girth to twist.*

ROPES MADE OF BAST FIBERS.

Fiber.	Girth.	Length of twist.	Twist ÷ girth.
	mm.	*mm.*	
Abroma fastuosa; unretted fiber	36	29	0.81
Abroma fastuosa; retted fiber	19	18	0.95
Commersonia bartramia	38	30	0.79
Helicteres hirsuta	35	30	0.86
Kleinhovia hospita	39	32	0.82
Pterocymbium tinctorium	42	34	0.81
Pterospermum diversifolium	21	18	0.86
Sterculia crassiramea	40	36	0.90
Sterculia foetida	22	20	0.91
Sterculia oblongata	38	32	0.84
Sterculia stipularis forma	22	17	0.77
Bombycidendron vidalianum	22	19	0.86
Malachra fasciata	17	16	0.94
Sida acuta	24	20	0.83
Thespesia lampas	30	27	0.90
Urena lobata var. *scabruscula*	21	18	0.86
Columbia blancoi	43	32	0.74
Corchorus olitorius	22	22	1.00
Grewia eriocarpa	20	18	0.90
Grewia multiflora	24	21	0.88
Grewia bilamellata	36	39	1.08
Allaeanthus glaber	39	30	0.77
Artocarpus communis	19	18	0.95
Do	30	30	1.00
Ficus benjamina	23	19	0.83
Ficus forstenii	22	18	0.82
Ficus pachyphylla	22	18	0.82
Ficus palawanensis	19	14	0.74
Cordia cumingiana	38	27	0.71
Cordia myxa	25	22	0.88
Gnetum sp	18	18	1.00
Bombax ceiba	26	26	1.00
Trema orientalis	26	21	0.81
Goniothalamus amuyon	29	23	0.79
Average			0.87

TABLE II.—*Twist of the ropes tested and the relationship of girth to twist*—Continued.

ROPES MADE OF MISCELLANEOUS FIBERS.

Fiber.	Girth.	Length of twist.	Twist : girth.
	mm.	*mm.*	
Musa textilis; grade "F" fiber[a]	31	30	0.97
Do	15	13	0.87
Musa textilis; grade "G" fiber[a]	26	25	0.96
Do	16	15	0.94
Commercial unclassified fiber	45	45	1.00
Do	24	25	1.04
Agave cantala; maguey Cebu No. 2[a]	26	21.5	0.83
Agave cantala; maguey from Santo Domingo, Ilocos Sur	23	17	0.74
Agave cantala; maguey from Sulvec, Ilocos Sur	25	21	0.84
Cocos nucifera; salt-water retted, from Caoayan, Ilocos Sur	50	38	0.76
Cocos nucifera; machine cleaned, from Laguna husks	44	37	0.84
Do	24	20	0.83
Corypha elata; leaf	47	40	0.85
Corypha elata; vascular fiber from petioles; buntal	22	20	0.91
Amomum sp	20	18	0.90
Anamirta cocculus; entire stem of vine twisted into a three-strand rope	44	40	0.91
Dendrocalamus merrillianus[b]	46	31	0.67
Average			0.87

[a] Machine-made rope; all other ropes are handmade.

[b] Two-strand rope; all other ropes have three strands.

resistant rope test specimens. This machine is of the lever type in which the test piece is held in a vertical position. The beam is graduated in 1,000- and the dial in 5-pound intervals. For testing the smaller ropes, a Riehlé testing machine of the helical spring-scale type was used. This machine is hand operated, by means of a flywheel having a crank, and has a capacity of 600 pounds. The dial is graduated in 1-pound intervals.

Tensile-strength tests.—The test specimens were prepared with an eye-splice at each end, the eyes having an internal diameter of 4.5 centimeters, and the splices having three tucks. The clear length of rope between the splices was either 50 or 100 centimeters, with 3 or 4 centimeters extra for marking. Upon this clear length of the test specimen the gauge length used for determining the elongation was laid off. Except as indicated, five test specimens were broken to give each average result. Plate II, fig. 2, represents typical test specimens.

One series of experiments was conducted upon test pieces in an air-dry condition. The results obtained from these specimens are designated throughout this paper as dry tests. Table

III gives the tensile strength per unit area of the ropes when tested in an air-dry condition.

Another series of tests was made upon specimens that had been entirely immersed in tap water for twenty-four hours. In Table IV are given the tensile strengths of the ropes tested after such immersion. The test pieces were broken imme-

TABLE III.—*Ropes made of Philippine fibers arranged in the order of mean tensile strength when dry, beginning with the strongest. The same results, arranged in a different order, are given in Table XLII.*

ROPES MADE OF BAST FIBERS.

No.	Fiber.	Mean dry tensile strength.	
		Per sq. cm.	Per sq. inch.
		Kilos.	*Lbs.*
1	*Gnetum* sp.	773	11,100
2	*Ficus palawanensis*	752	10,700
3	*Abroma fastuosa;* retted	643	9,100
4	*Malachra fasciata*	637	9,030
5	*Bombycidendron vidalianum*	630	8,940
6	*Abroma fastuosa;* crude strips	545	7,760
7	*Corchorus olitorius*	503	7,130
8	*Urena lobata*	482	6,850
9	*Ficus benjamina*	480	6,830
10	*Sida acuta*	475	6,760
11	*Ficus pachyphylla*	464	6,600
12	*Helicteres hirsuta*	438	6,230
13	*Bombax ceiba*	405	5,720
14	*Sterculia oblongata*	398	5,650
15	*Sterculia crassiramea*	398	5,660
16	*Grewia eriocarpa*	394	5,630
17	*Commersonia bartramia*	392	5,580
18	*Cordia cumingiana*	388	5,500
19	*Pterocymbium tinctorium*	381	5,420
20	*Grewia multiflora*	376	5,360
21	*Artocarpus communis;* old bast	367	5,220
22	*Artocarpus communis;* young bast	356	5,070
23	*Goniothalamus amuyon*	345	4,940
24	*Cordia myxa*	324	4,610
25	*Grewia bilamellata*	320	4,570
26	*Kleinhovia hospita*	309	4,370
27	*Columbia blancoi*	302	4,270
28	*Sterculia stipularis*	268	3,800
29	*Thespesia lampas*	268	3,800
30	*Pterospermum diversifolium*	263	3,740
31	*Allaeanthus glaber*	231	3,290
32	*Sterculia foetida*	200	2,840
33	*Ficus forstenii*	154	2,200
34	*Trema orientalis*	134	1,920
	Average	406	5,770

TABLE III.—*Ropes made of Philippine fibers arranged in the order of mean tensile strength when dry, etc.*—Continued.

ROPES MADE OF MISCELLANEOUS FIBERS.

No.	Fiber.	Mean dry tensile strength.	
		Per sq. cm.	Per sq. inch.
		Kilos.	*Lbs.*
1	*Musa textilis;* grade "G" abacá; rope, 16 mm. in circumference [a]	1,110	15,700
2	*Musa textilis;* grade "F" abacá; rope, 15 mm. in circumference [a]	974	13,800
3	*Musa textilis;* grade "F" abacá; rope, 31 mm. in circumference [a]	943	13,400
4	*Musa textilis;* grade "G" abacá; rope, 26 mm. in circumference [a]	744	10,600
5	*Agave cantala;* maguey; grade, Cebu No. 2 [a]	739	10,400
6	*Dendrocalamus merrillianus* [b]	237	3,380
7	*Corypha elata;* leaf of palm	232	3,300
8	*Corypha elata;* buntal; vascular fibers in petioles	222	3,150
9	*Cocos nucifera;* rope, 50 mm. in circumference [c]	185	2,640
10	*Cocos nucifera;* rope, 24 mm. in circumference [d]	176	2,490
11	*Cocos nucifera;* rope, 44 mm. in circumference [d]	170	2,420
12	*Anamirta cocculus* [e]	149	2,120
	Average	490	6,950

[a] Machine-made rope; all other ropes are handmade.

[b] This rope has two strands only; all other ropes have three strands.

[c] Rope made at Caoayan, Ilocos Sur, from salt-water retted coir.

[d] Rope made of coir that had been machine cleaned at the Bureau of Science from Laguna husks.

[e] Rope made of the entire stem of the vine.

diately at the end of this period, while still saturated, and are referred to as wet tests.

Elongation.—The test specimens were fixed in the testing machine in a vertical position by passing steel pins 40 millimeters in diameter through the eyes of the splices; they were subjected to an initial tension not exceeding 5 pounds, to facilitate marking the gauge length, which was either 50 or 100 centimeters, and were measured to an accuracy of 0.5 centimeter. The load was then applied at a uniform rate so that the specimens stretched 1.3 millimeters per second; therefore, the total elongation divided by 1.3 gave the duration of the test. During the time the load was being applied the zero of a scale graduated in 0.5 centimeter was constantly kept aligned with the lower gauge mark, the progress of the upper gauge mark was constantly noted, and the reading on the scale was recorded when the specimen broke. The difference between this reading and the gauge length gave directly the elongation which, when divided by the gauge length and multiplied by 100, gave the percentage of elongation. The elongations recorded are sufficiently accurate to give the percentages in the nearest whole per cent.

Breaking length.—Stresses of yarns, strands, and rope during tensile-strength tests are not distributed uniformly, but are more or less localized because of the heterogeneous nature of fiber bodies and the various mechanical defects. As a rule, nearly all vegetable-fiber ropes of three and four strands, including those here studied, break in one strand, seldom in two, and very

TABLE IV.—*Ropes made of Philippine fibers arranged in order of mean tensile strength when wet, beginning with the strongest. The same results, arranged in a different order, are given in Table XLII.*

ROPES MADE OF BAST FIBERS.

No.	Fiber.	Mean wet tensile strength.	
		Per sq. cm.	Per sq. inch.
		Kilos.	*Lbs.*
1	*Gnetum* sp.	1,000	14,500
2	*Ficus palawanensis*	766	10,900
3	*Ficus pachyphylla*	544	7,760
4	*Malachra fasciata*	543	7,700
5	*Sida acuta*	502	7,190
6	*Ficus benjamina*	471	6,700
7	*Bombycidendron vidalianum*	468	6,670
8	*Pterocymbium tinctorium*	435	6,180
9	*Helicteres hirsuta*	396	5,620
10	*Grewia eriocarpa*	381	5,460
11	*Urena lobata*	366	5,200
12	*Sterculia stipularis;* forma	366	5,200
13	*Cordia cumingiana*	364	5,160
14	*Corchorus olitorius*	360	5,100
15	*Bombax ceiba*	351	4,960
16	*Artocarpus communis;* bast from young tree	340	4,830
17	*Grewia multiflora*	332	4,730
18	*Abroma fastuosa;* unretted bast	319	4,530
19	*Sterculia crassiramea*	308	4,380
20	*Columbia blancoi*	306	4,340
21	*Goniothalamus amuyon*	293	4,180
22	*Thespesia lampas*	291	4,130
23	*Sterculia oblongata*	291	4,130
24	*Kleinhovia hospita*	286	4,070
25	*Commersonia bartramia*	266	3,780
26	*Cordia myxa*	263	3,730
27	*Trema orientalis*	262	3,720
28	*Pterospermum diversifolium*	261	3,690
29	*Allaeanthus glaber*	253	3,590
30	*Ficus forstenii*	222	3,160
31	*Sterculia foetida*	200	2,840
32	*Grewia bilamellata*	180	2,670
	Average	375	5,338

TABLE IV.—*Ropes made of Philippine fibers arranged in order of mean tensile strength when wet, etc.*—Continued.

ROPES MADE OF MISCELLANEOUS FIBERS.

No.	Fiber.	Mean wet tensile strength.	
		Per sq. cm.	Per sq. inch.
		Kilos.	*Lbs.*
1	*Musa textilis;* grade "G" abacá; rope, 16 mm. in circumference[a]	1,180	16,700
2	*Musa textilis;* grade "F" abacá; rope, 31 mm. in circumference[a]	946	13,500
3	*Musa textilis;* grade "F" abacá; rope, 15 mm. in circumference[a]	923	13,100
4	*Musa textilis;* grade "G" abacá; rope, 26 mm. in circumference[a]	759	10,800
5	*Agave cantala;* maguey; grade, Cebu No. 2[a]	651	9,220
6	*Amomum* sp	325	4,600
7	*Corypha elata;* buntal; vascular fibers in petioles	257	3,650
8	*Dendrocalamus merrillianus*[b]	179	2,540
9	*Cocos nucifera;* rope, 24 mm. in circumference[c]	148	2,100
10	*Cocos nucifera;* rope, 44 mm. in circumference[d]	146	2,070
11	*Cocos nucifera;* rope, 50 mm. in circumference[e]	136	1,940
12	*Anamirta cocculus*[f]	110	1,570
	Average	480	6,816

[a] Machine-made rope; all other ropes are handmade.

[b] This rope has two strands only; all other ropes have three strands.

[c] Immersed in stagnant tap water twenty-one days before testing; all other ropes were steeped in tap water only twenty-four hours before being tested. Rope made of fiber that had been machine cleaned at the Bureau of Science from Laguna husks.

[d] Rope made of fiber that had been machine cleaned at the Bureau of Science from Laguna husks.

[e] Rope made at Caoayan, Ilocos Sur, from salt-water retted coir.

[f] Three-strand rope made of the entire stem of the vine.

rarely in three; this shows that the various strands are not equally taut in manufacture, and that the intensity of stress is greater in some fibers than in others.

As a substitute for stresses calculated on the basis of sectional areas of cordage and similar material (paper, leather, etc.), the computation of whose solid sectional area presents difficulties, Reuleaux[13] in 1861, and Rankine[13] in 1866, introduced the concept of breaking length. The breaking length of a rope is that length which when suspended at one end will cause the specimen to break of its own weight. It is computed by dividing the breaking load or tensile strength in pounds or kilograms by the weight in pounds per foot or in kilograms per meter, respectively, as follows:

$$\frac{\text{Breaking load}}{\text{Weight per unit length}} = \text{Breaking length.}$$

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[13] Heermann, Paul, Mechanisch- und Physikalisch-technische Textile-Untersuchung. Julius Springer, Berlin (1912) 160–161.

Ropes made of the strongest and lightest fiber give the highest breaking length. However, a rope having a comparatively low breaking load (represented by the numerator of the equation) but having a relatively small weight per unit length (given by the denominator of the equation) would also give a high breaking length. Rope possessed of a very high breaking load and a relatively high mass per unit length might still give a high breaking length.

TABLE V.—*Breaking lengths of Philippine handmade bast-fiber ropes and miscellaneous hand- and machine-laid fiber ropes. The same results, arranged in a different order, are given in Table XLII.*

✓ ROPES MADE OF BAST FIBERS.

No.	Fiber.	Mean breaking length.	
		Meters.	*Feet.*
1	*Gnetum* sp.	8,450	27,700
2	*Abroma fastuosa;* retted bast	7,740	25,400
3	*Malachra fasciata*	7,680	24,800
4	*Bombycidendron vidalianum*	6,950	22,800
5	*Ficus palawanensis*	6,230	20,400
6	*Urena lobata*	6,180	20,300
7	*Abroma fastuosa;* crude strips	5,770	18,900
8	*Sida acuta*	5,770	18,900
9	*Corchorus olitorius*	5,420	17,800
10	*Grewia eriocarpa*	5,050	16,600
11	*Sterculia crassiramea*	5,050	16,600
12	*Ficus benjamina*	5,030	16,500
13	*Ficus pachyphylla*	4,930	16,200
14	*Bombax ceiba*	4,620	15,150
15	*Artocarpus communis;* old bast	4,560	14,900
16	*Pterocymbium tinctorium*	4,560	14,900
17	*Sterculia oblongata*	4,490	14,700
18	*Artocarpus communis;* young bast	4,450	14,600
19	*Cordia cumingiana*	4,450	14,600
20	*Cordia myxa*	4,125	13,500
21	*Commersonia bartramia*	4,070	13,300
22	*Helicteres hirsuta*	3,950	12,950
23	*Kleinhovia hospita*	3,870	12,700
24	*Grewia bilamellata*	3,810	12,500
25	*Goniothalamus amuyon*	3,680	12,050
26	*Grewia multiflora*	3,660	12,000
27	*Columbia blancoi*	3,510	11,500
28	*Thespesia lampas*	3,180	10,400
29	*Sterculia stipularis*	2,980	9,780
30	*Pterospermum diversifolium*	2,620	8,620
31	*Allaeanthus glaber*	2,440	8,030
32	*Sterculia foetida*	1,964	6,450
33	*Ficus forstenii*	1,600	5,260
34	*Trema orientalis*	1,420	4,660

TABLE V.—*Breaking lengths of Philippine handmade bast-fiber ropes and miscellaneous, etc.*—Continued.

ROPES MADE OF MISCELLANEOUS FIBERS.

No.	Fiber.	Mean breaking length.	
		Meters.	*Feet.*
1	*Musa textilis;* grade "F" abacá; rope, 31 mm. in circumference[a]	12,300	40,400
2	*Musa textilis;* grade "F" abacá; rope, 15 mm. in circumference[a]	11,900	39,000
3	*Musa textilis;* grade "G" abacá; rope, 16 mm. in circumference[a]	10,200	33,300
4	*Agave cantala;* maguey; grade, Cebu No. 2[a]	9,350	30,700
5	*Musa textilis;* grade "G" abacá; rope, 26 mm. in circumference[a]	8,390	27,500
6	*Amomum* sp.	5,530	18,150
7	*Dendrocalamus merrillianus*[b]	3,800	12,450
8	*Corypha elata;* buntal	3,700	12,100
9	*Cocos nucifera;* rope, 24 mm. in circumference	3,550	11,650
10	*Anamirta cocculus*[c]	3,200	10,500
11	*Cocos nucifera;* rope, 44 mm. in circumference[d]	2,730	8,950
12	*Cocos nucifera;* rope, 50 mm. in circumference[e]	2,620	8,610

[a] Machine-made rope; all other ropes are handmade.

[b] This rope has two strands only; all other ropes have three strands.

[c] Rope made of the entire stem of the vine.

[d] Rope made of coir that had been machine cleaned at the Bureau of Science from Laguna husks.

[e] Rope made at Caoayan, Ilocos Sur, from salt-water retted coir.

In Table V ropes made of Philippine fibers are arranged in two groups.

The first group is devoted to handmade bast-fiber ropes and the second to hand- and machine-made ropes of miscellaneous fibers. The order of succession is not always the same, as will be seen by a comparison of the relative positions given to the various fibers in Tables IV and V; in the latter they are listed in the order of their breaking length, while in the former they are tabulated in the order of their dry tensile strength per unit area. The tensile strength per unit area does not take into consideration the actual weight of the fiber, and the two series must necessarily vary whenever there is a variation in the specific gravity of the materials. Rope made of the fiber of *Helicteres hirsuta* ranks ninth in tensile strength, but twenty-second when classified as to its breaking length. This irregularity is readily comprehended by reference to Table XLII, which shows that the rope made of this fiber is one of the heaviest tested.

Moisture.—Three pieces, each about 20 centimeters long, were cut from three different places in each coil of rope, and the samples were dried to constant weight at a temperature of 103° C. in a Freas electric oven. The dry weight was taken as the basis on which to compute the percentage of moisture. The figures given in Table VI show the mean of three closely agreeing determinations for each of the fibers tested.

TABLE VI.—*Percentage loss of moisture in ropes when dried at 103° C. to constant weight.*

ROPES MADE OF BAST FIBERS.

Fiber.	Moisture. Per cent.
Abroma fastuosa; unretted fiber	15.0
Abroma fastuosa; retted fiber	16.6
Commersonia bartramia	15.8
Helicteres hirsuta	14.6
Kleinhovia hospita	16.8
Pterocymbium tinctorium	13.5
Pterospermum diversifolium	10.7
Sterculia crassiramea	13.2
Sterculia foetida	9.7
Sterculia oblongata	15.0
Sterculia stipularis	9.0
Bombycidendron vidalianum	9.4
Malachra fasciata	9.3
Sida acuta	9.5
Thespesia lampas	8.9
Urena lobata var. *scabruscula*	10.8
Columbia blancoi	13.6
Corchorus olitorius	10.3
Grewia eriocarpa	9.1
Grewia multiflora	15.1
Grewia bilamellata	9.8
Allaeanthus glaber	16.1
Artocarpus communis; young bast	10.2
Artocarpus communis; old bast	17.3
Ficus benjamina	9.2
Ficus forstenii	10.7
Ficus pachyphylla	10.0
Ficus palawanensis	10.0
Cordia cumingiana	14.5
Cordia myxa	9.3
Gnetum sp.	12.9
Bombax ceiba	18.8
Trema orientalis	9.8
Goniothalamus amuyon	9.5

ROPES MADE OF MISCELLANEOUS FIBERS.

Agave cantala; maguey from Santo Domingo, Ilocos Sur	18.9
Agave cantala; maguey from Sulvec, Ilocos Sur	23.5
Cocos nucifera; retted fiber from Caoayan, Ilocos Sur	11.7
Corypha elata; leaf	14.7
Corypha elata; vascular fibers from petioles; buntal	10.6
Amomum sp.	9.8
Anamirta cocculus [a]	11.13
Dendrocalamus merrillianus [b]	13.6

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[a] Entire stem of vine twisted into three-strand rope.

[b] Two-strand rope.

Color.—In determining the color of the bast fibers discussed in this paper the color nomenclature of Ridgway[14] was used.

Length of bast strips.—In order to ascertain the average length of the bast strips, or ribbons, constituting the ropes tested, a 6-meter section was untwisted and measured. In Table VII are given the maximum, minimum, and mean lengths of the strips of bast from twenty-one species.

TABLE VII.—*Length of crude bast strips composing some of the ropes tested.*

Fiber.	Length.		Mean of five strips measured.
	Maximum.	Minimum.	
	mm.	*mm.*	*mm.*
Abroma fastuosa; unretted bast	912	356	675
Pterocymbium tinctorium	3,113	305	1,889
Sterculia crassiramea	3,010	277	1,890
Sterculia oblongata	3,066	184	2,111
Sterculia foetida	1,036	235	767
Sterculia stipularis; forma	1,248	206	980
Bombycidendron vidalianum	990	300	657
Thespesia lampas	1,555	542	1,203
Urena lobata	1,950	176	1,118
Corchorus olitorius	1,668	198	1,186
Grewia eriocarpa	1,592	290	1,004
Grewia bilamellata	1,343	346	1,060
Grewia multiflora	2,476	1,482	2,104
Artocarpus communis	927	160	610
Ficus benjamina	1,388	1,053	1,227
Ficus forstenii	1,095	346	738
Ficus pachyphylla	1,884	239	838
Ficus palawanensis	1,240	325	821
Gnetum sp.	851	239	503
Bombax ceiba	1,595	303	967
Goniothalamus amuyon	1,063	295	794

The strongest rope, *Gnetum* sp., is made of bast strips having the shortest length, which shows that even with these lengths the resistance to slipping is greater than the actual strength of the fiber in the other cases.

LOCAL PHILIPPINE NAMES

Most of the local Philippine names of the species yielding bast fiber recorded in this paper were obtained from the descriptive labels accompanying botanical specimens in the Bureau of Science herbarium, and from Schneider.[15] Others were obtained while studying the bast-rope industry in the Ilocos Provinces.

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[14] Ridgway, R., Color Standards and Color Nomenclature. Published by the author in Washington, D. C. (1912).

Local Philippine names are given on account of their helpfulness in identifying plant species, but they must always be used with caution, because they are at times applied with extreme looseness. Several related species may all be known by one name; on the other hand, one species may be known by several different names in the same place and in the same dialect. For example, *Kleinhovia hospita* is called *marakapas* by the Ilocanos of Ilocos Sur, but the same term is also applied to a closely related species, *Pterocymbium tinctorium*, and to *Thespesia lampas*, which belongs to an entirely different family. In the same way *annabo* is applied to two species that belong to altogether different families; namely, *Malachra fasciata* and *Abroma fastuosa*. *Maratarong* is used to denominate both *Thespesia lampas* and *Cordia cumingiana*.

STERCULIACEAE

ABROMA FASTUOSA Jack. (*Abroma augusta* L.). Anabo.

Common names: Abroma, devil's cotton (English); *abrome* (French); *Kakaomalve*, *Abrome* (German).

Local names: *Ambong* (Tagalog); *an-nabó*, *anabó* or *annabó* (Abra, Apayao, Bataan, Benguet, Ilocos Norte, Ilocos Sur, Laguna, Manila, Negros, Rizal, Tayabas, Union); *anabong*, *labon*, *nabó*, *sayapo* (Visayan, Cotabato, Negros, Rizal); *anabú*, *pakalkal* (Pampanga); *anafu* (Nueva Vizcaya); *bago* (Sorsogon); *bodobodo* (Ilocos Norte); *nabu* (Bohol, Cagayan, Negros); *negegan* (Batanes); *sayapu* (Moro in Cotabato).

A shrub; the vegetative parts covered with stiff, somewhat irritating hairs; leaves heart-shaped, 10 to 30 centimeters long; flowers yellow, about 5 centimeters in diameter; capsules thin-walled, truncate, five-angled, five-winged, five-valved; widely distributed in the settled areas of the Philippines at low and medium altitudes; sometimes cultivated.

Various statements have appeared from time to time with regard to *Abroma fastuosa*—that it is more easily cultivated than jute, that it yields at least three crops of fiber yearly, etc. Although it is mentioned by Watt,[16] *Abroma fastuosa* bast can hardly be considered to have attained commercial significance. Even in India, where the plant is very abundant and where, since its discovery by Roxburgh in 1801, the greatest efforts have been exerted to make it of commercial importance, the results have not been successful.

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[15] Schneider, E. E., Commercial Woods of the Philippines: Their Preparation and Uses, *Bull. P. I. Bur. Forestry* 14 (1916). Mr. Schneider, wood expert, has revised the local names used in this paper, in accordance with the spellings adopted by the Philippine Bureau of Forestry.

[16] Watt, G., The Commercial Products of India. John Murray, London (1908) 1.

Cultivation experiments[17] with two lots of seed, performed at the Forestry School and on the farm of the College of Agriculture at Los Baños, Philippine Islands, were unsuccessful. The first lot gave a germination percentage of only 4, and the second, 20.5. At the end of a year the plants were 2.1 meters high and averaged 4.4 centimeters in diameter at the base. These plants were blown over during a storm eight days prior to their having attained an age of one year, but were subsequently righted. No details are given regarding the later progress of the plants or the quality and yield of the fiber produced. Mendiola[18] suggests the suitability of *Abroma fastuosa* for reforestation, since it grows on cogon areas and can check the growth of grass within a year. Aside from these experiments *Abroma fastuosa* has never been cultivated in the Philippines. It grows wild in at least fifteen provinces, and the fiber used locally is procured from this very uncertain and limited source. On one of the Bureau of Science herbarium sheets on which a specimen of *Abroma fastuosa* is mounted it is stated that this bast fiber is used in Cotabato as a substitute for abacá and that it sells for from 6 to 8 pesos per picul. It is stated also that in Cebu the fiber is quoted at 6.50 pesos and that it sometimes is sold for 10 pesos per picul, and that considerable quantities are brought to Cebu from Dipolog and Dapitan.

Tests and discussion of results.—Two samples of *Abroma fastuosa* rope were tested, photographs of which are shown in Plate III, figs. 1 and 2. Although these are from accurately identified plant specimens their physical appearance is sufficiently different to lead one to doubt their identity. That shown in fig. 1 was taken from a coil of rope collected by me at Sappaac, Abra Province, May, 1916. The fiber was prepared by retting for about ten days in fresh water with subsequent manipulation. It is sulphur yellow, soft and glossy, and makes a very pliable and attractive-looking rope. It has a high uniform tensile strength which compares favorably with machine-made abacá rope, and in breaking length it is only second to *Gnetum* sp.

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[17] Mendiola, Nemesio Blanco, A study of Philippine bast fibers, *Philip. Agr. and Forester* 6 (1917) 6–38.

[18] Loc. cit.

Some of the strips of bast have been freed so thoroughly from the adherent cellular tissue that the individual filaments are easily discernible and present a silky appearance; in fact, Watt[19] states that the fiber might be considered a substitute for silk. The rope was made of fiber that was already on hand at the time of my visit, and therefore represents the bast as it is customarily used there for cordage manufacture. Plate II, fig. 1, shows the process of laying this retted-rope sample, together with details of the triple-crank end of the primitive wooden apparatus employed for the purpose. The other specimen, shown in Plate III, fig. 2, is cream buff and was collected at Disdis, Benguet Subprovince, for this particular work, by Eugenio Fénix, formerly botanical assistant, Bureau of Science. In this place the Filipinos did not take the trouble to clean the bast by retting or other process; they simply used the crude ribbonlike strips, which average 5 millimeters wide, 0.51 millimeter thick, and 675 millimeters long, in manufacturing the rope. Each strand is about seven strips thick. The result is a bulky, coarse, and rough-looking rope of erratic tensile strength when either wet or dry. Although inferior in strength to the retted-fiber rope, due to the large percentage of inert material encumbering its filaments, nevertheless it has more than average tenacity.

The retted bast-fiber rope has a uniformly high tensile strength, and breaks of dry specimens occurred at 147, 157, and 166 kilograms, respectively, a maximum variation of only 6 per cent from the mean. All three of the test specimens failed outside of eye-splices. On the other hand specimens of the uncleaned bast rope in a series of five tests gave a maximum tensile variation of 21 per cent from the mean value. Two of the specimens ruptured in eye-splices.

No tests were made of the wetted rope specimens fabricated of retted fiber. Wetting the rope made from crude strips of *Abroma fastuosa* bast lowered its mean tensile strength nearly 50 per cent, with a maximum variation in five specimens of 22 per cent from the mean. One specimen ruptured in an eye-splice. It would appear that this fiber is unsuitable for use in the wetted condition. Its unsuitability in wet places is appreciated by the Filipinos, who largely restrict its use to the dry season. When dry it is much valued and is preferred for hanging clothes because it is nonstaining.

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[19] Watt, G., Dictionary of the Economic Products of India. Government of India Printing Office, Calcutta 1 (1885) 7 and 8.

TABLE VIII.—*Physical tests of rope made of Abroma fastuosa.*

	Crude fiber strips; not retted.[a]	Retted fiber; fairly clean.[b]
Mean diameter:		
Millimeters	11.5	6.1
Inches	0.45	0.24
Mean perimeter, or girth:		
Millimeters	36	19
Inches	1.42	0.75
True mean sectional area:		
Square millimeters	88.4	24.4
Square inches	0.137	0.037
Ultimate tensile strength (dry):		
Mean in kilograms	482	157
Maximum in kilograms	583	166
Minimum in kilograms	388	147
Mean in pounds	1,063	345
Maximum in pounds	1,285	365
Minimum in pounds	855	325
Ultimate tensile strength (wet):		
Mean in kilograms	282	(c)
Maximum in kilograms	336	(c)
Minimum in kilograms	220	(c)
Mean in pounds	621	(c)
Maximum in pounds	740	(c)
Minimum in pounds	485	(c)
Mean ultimate tensile strength per unit area (dry):		
Kilograms per square centimeter	545	643
Pounds per square inch	7,760	9,100
Mean ultimate tensile strength per unit area (wet):		
Kilograms per square centimeter	319	(c)
Pounds per square inch	4,530	(c)
Mean elongation at instant of rupture:		
Dry ... per cent	12	(c)
Wet ... do	13	(c)
Mean weight per unit length:		
Grams per meter	83.7	20.2
Pounds per foot	0.0562	0.0136
Average breaking length:		
Meters	5,770	7,740
Feet	18,900	25,400
Moisture ... per cent	13.67	14.3

[a] Made at Disdis, Benguet Subprovince. [b] Made at Sappaac, Abra Province. [c] No test made.

Comparative tests performed by Roxburgh[20] on the tensile strength of two "lines" made of *Abroma fastuosa* bast in the dry and wet condition, respectively, show an average gain of 12 pounds for the wetted line made from the fiber procured from young shoots cut before the blossoms appeared, and no gain in strength for the wetted line made from the bast obtained from old ligneous plants that had ripened their seed. The test specimens, which were apparently suspended at one end, had a length of 4 feet and were ruptured by the addition of weights; no mention is made of the rate of increment of load, the period of immersion, the kind of water used, the diameter or circumference of the test specimens, how the lines were made, or the percentage elongation. Consequently these tensile-strength data cannot be compared with those obtained in this investigation. Roxburgh's[21] data as published by Royle are in the following form; I have omitted the results given for twenty-seven lines made from other species:

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[20] Through Royle, Forbes, Fibrous Plants of India Fitted for Cordage, Clothing, and Paper. Smith, Elder and Co., London; Smith, Taylor and Co., Bombay (1855) 268.

Comparative strength of Fibres, both dry and wet, ascertained by weights suspended to four-feet lengths of the several lines.

No.	NAMES OF THE PLANTS, And brief Remarks on the various Materials employed in these Experiments.	Average weight each line broke when dry.	Average weight each line broke when wet.	Average of weight gained by wetting the lines.
15	Abroma augusta, young shoots cut before the blossoms appeared	100	112	12
16	The same, from old ligneous plants, that had ripened their seed	121	121	0

A summary of the tests made in the Bureau of Science is given in Table VIII.

COMMERSONIA BARTRAMIA (Linn.) Merr. Kakaag.

Local names: *Anitap* (Itneg, Benguet); *kakaag* (Ilocano, Benguet).

A small tree with heart-shaped, softly pubescent leaves; terminal panicles of small white flowers, the capsules five-valved, globose, densely covered with slender, hairy, soft processes; throughout the Philippines at low altitudes.

The color of the crude *Commersonia bartramia* bast strips constituting the sample of cordage examined varies from a light ochraceous salmon to a warm buff. Each strand averages five bast strips in thickness, the strips varying in width from 4 to 10 millimeters and in thickness from 0.28 to 0.74 millimeter.

The results of the tensile-strength tests of five dry specimens show medium tenacity although in poor agreement, with a maximum variation of 20 per cent from the mean. Four of the test pieces ruptured in eye-splices.

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[21] Loc. cit.

Tensile-strength tests of five specimens that had been immersed in tap water for twenty-four hours showed a reduction of 32 per cent in strength, with a maximum variation from the mean of 26 per cent. Only one specimen broke in an eye-splice. Due to the marked impairment in strength occasioned by wetting, it would seem that cordage made of wetted *Commersonia bartramia* bast is unsuited for use. Nevertheless the residents of Benguet, where the rope was procured, state that during rainy weather it is more durable than the other commonly used basts, and that it is considered primarily a wet-weather rope.

A summary of the tests made in the Bureau of Science is given in Table IX.

TABLE IX.—*Physical tests of rope made from the bast of Commersonia bartramia.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	12.1
Inches	0.48
Mean perimeter, or girth:	
Millimeters	38
Inches	1.50
True mean sectional area:	
Square millimeters	97.5
Square inches	0.151
Ultimate tensile strength (dry):	
Mean in kilograms	382
Maximum in kilograms	458
Minimum in kilograms	306
Mean in pounds	843
Maximum in pounds	1,010
Minimum in pounds	675
Ultimate tensile strength (wet):	
Mean in kilograms	259
Maximum in kilograms	327
Minimum in kilograms	220
Mean in pounds	570
Maximum in pounds	720
Minimum in pounds	485
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	392
Pounds per square inch	5,580
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	266
Pounds per square inch	3,780
Mean elongation at instant of rupture:	
Dry (per cent)	14
Wet (per cent)	13

TABLE IX.—*Physical tests of rope made from the bast of Commersonia bartramia*—Continued.

Mean weight per unit length:	
Grams per meter	93.9
Pounds per foot	0.0632
Average breaking length:	
Meters	4,070
Feet	13,300
Moisture (per cent)	13.62

HELICTERES HIRSUTA Lour.

Local names: *Balibago bulbusin* (Pampanga); *buntot-usá, lailaiginan* (Rizal); *danglin aso* (Visayan); *danglin kalabau* (Abra, Pangasinan, Tarlac); *kakaab* or *kakaag* (Union, Pangasinan); *kakaag* (Abra, Pangasinan); *kol-lokol-lot ti bao* (Benguet); *kubal* (Pangasinan); *luginlaginan* (Manila and vicinity); *malamansanita* (Ilocos Norte, Tagalog); *malatakon* (Abra); *pakin bakit* (Ilocano); *saginsaginan* (Tagalog); *sarungas á dadakkel* (Ilocos Sur); *talakau* (Negrito); *talosan* (Tayabas); *tolosan* (Ilocano); *tongtongking* (Amburayan).

A shrub with soft, hairy, oblong, acuminate leaves which are obliquely cordate at the base; cymes axillary; flowers pink or purplish, slender, nearly 2 centimeters long, capsule oblong, cylindric, 3 to 4 centimeters long, beaked, very shaggy; throughout the Philippines at low altitudes, locally very abundant.

The fiber strips constituting this rope are light buff, harsh, and stiff. Some of the coarser ribbons have a decidedly woody appearance. The thicker ribbons are not so pliable as the thinner ones and are, moreover, marked with scars or perforations showing where twigs or branches grew from the stems. Each strand is from nine to eleven strips in thickness, the strips varying in width from 3 to 11 millimeters, and in thickness from 0.18 to 0.76 millimeter. It will be noticed that there is great variability in the dimensions of the strips.

Both the tensile strength and the breaking length of this rope are low. Twenty-four hours' immersion in water reduced the tensile strength only about 10 per cent. From field information it appears that rope made from this bast is durable during the rainy season. The individual breaks in both the dry and the wet series gave good agreement; the maximum variation from the mean tensile strength of the five dry test pieces was 17 per cent, and the corresponding value for the wet series was 11 per cent. All of the dry specimens failed outside of eye-splices, and two of the wet test pieces ruptured in eye-splices.

A summary of the tests made in the Bureau of Science is given in Table X.

TABLE X.—*Physical tests of rope made from the bast of Helicteres hirsuta.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	11.2
Inches	0.44
Mean perimeter, or girth:	
Millimeters	35
Inches	1.38
True mean sectional area:	
Square millimeters	78.6
Square inches	0.122
Ultimate tensile strength (dry):	
Mean in kilograms	345
Maximum in kilograms	404
Minimum in kilograms	306
Mean in pounds	761
Maximum in pounds	890
Minimum in pounds	675
Ultimate tensile strength (wet):	
Mean in kilograms	311
Maximum in kilograms	331
Minimum in kilograms	277
Mean in pounds	685
Maximum in pounds	730
Minimum in pounds	610
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	438
Pounds per square inch	6,230
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	396
Pounds per square inch	5,620
Mean elongation at instant of rupture:	
Dry (per cent)	13
Wet (per cent)	13
Mean weight per unit length:	
Grams per meter	87.4
Pounds per foot	0.0587
Average breaking length:	
Meters	3,950
Feet	12,950
Moisture (per cent)	12.71

KLEINHOVIA HOSPITA Linn. Tanag.

Local names: *Bafe ñga bunsung* (Nueva Vizcaya); *bantana* (Guimaras); *biknong* (Union, Zambales); *biluan, lapnis, malobago* (Negros); *biluan* (Occidental Negros); *binong* (Nueva Ecija, Pangasinan); *binunga* (Bataan); *bitanag* (Agusan, Surigao); *bitnong* (Ilocano); *bitonág* (Visayan); *bitonog* (Lanao); *butnong, taloktok* (Ilocos Norte); *hamitanago* (Visayan); *hunung* (Cagayan); *magindanau, tamanag* (Cotabato); *malibago* (Palawan); *marakapas* (Ilocos Sur); *pampar, panampat* (Pampanga); *tanág* or *tap-ag* (Bicol, Visayan, Ilocano, and Tagalog); *tanak* (Tayabas); *unapong* (Balabac); *unopong* (Moro).

A small or medium-sized tree with large, cordate, broadly ovate leaves, and ample terminal panicles of small pink flowers; capsules inflated, thin-walled, about 2 centimeters long, obovoid; throughout the Philippines at low altitudes; usually abundant.

According to Mendiola[22] *Kleinhovia hospita* can be made to produce at least two crops a year of shoots about 1 meter long. It is grown from seed, and all attempts to propagate it from cuttings have failed. The tree is found in Malacca, Singapore, Ceylon, Java, and tropical East Africa. It is grown as an avenue tree in India, especially in Calcutta.

In appearance and general structure the bast strips of *Kleinhovia hospita* are much like those of *Sterculia crassiramea;* the sample of rope made from the former also has the frayed and irregular characteristics of rope made from the latter. The strands average nine strips of bast in thickness, and the strips average 5 millimeters in width and vary from 0.43 millimeter to 1.75 millimeters in thickness.

The sample of rope when dry is low in tensile strength and in breaking length. Unlike some related species, the wetted fiber shows relatively little decrease in tensile strength; immersion in water for twenty-four hours reduced the mean tensile strength only 7 per cent. However, the maximum result in the two series was in that of a wet specimen. The Filipinos state that cordage made of this fiber is durable during rainy weather.

All ruptures of the dry specimens occurred outside, whereas two out of the five wet test pieces broke inside of eye-splices. The minimum as well as the maximum values in the wet series were obtained from test specimens that failed outside of eye-splices. The maximum variations from the mean tensile strength in the dry and the wet series were 17 and 30 per cent, respectively.

Like most of the ropes tested, this one is principally used for tethering carabaos and horses and for making halters. The individual ribbons of *Kleinhovia hospita* bast, after being torn into fine strips, are used as binder twine for tying rice stalks.

A summary of the tests made in the Bureau of Science is given in Table XI.

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[22] Philip. Agr. and Forester 6 (1917).

TABLE XI.—*Physical tests of rope made from the bast of Kleinhovia hospita.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	12.4
Inches	0.49
Mean perimeter, or girth:	
Millimeters	39
Inches	1.54
True mean sectional area:	
Square millimeters	116.6
Square inches	0.181
Ultimate tensile strength (dry):	
Mean in kilograms	360
Maximum in kilograms	403
Minimum in kilograms	299
Mean in pounds	793
Maximum in pounds	890
Minimum in pounds	660
Ultimate tensile strength (wet):	
Mean in kilograms	334
Maximum in kilograms	435
Minimum in kilograms	272
Mean in pounds	737
Maximum in pounds	960
Minimum in pounds	600
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	309
Pounds per square inch	4,370
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	286
Pounds per square inch	4,070
Mean elongation at instant of rupture:	
Dry (per cent)	13
Wet (per cent)	13
Mean weight per unit length:	
Grams per meter	92.9
Pounds per foot	0.0625
Average breaking length:	
Meters	3,870
Feet	12,700
Moisture (per cent)	14.49

PTEROSPERMUM DIVERSIFOLIUM Bl. Bayok.

Local names: *Baloi* and *bároi* (Abra, Ilocos Sur, Pangasinan, Tarlac); *baroi* (Abra, Benguet, Ilocano, Itneg); *bayog-bayóg* (Zamboanga); *bayóg, bayók,* or *bayok* (Bataan, Batangas, Camarines, Catanduanes, Cavite, Cotabato, Laguna, Masbate, Mindoro, Negros, Nueva Ecija, Palawan, Pampanga, Rizal, Tayabas, Ticao, Zambales, and Zamboanga); *biyug, bayong* (Tayabas); *dibuál* (Basilan); *taliñgaan* (Ilocos Norte).

A small tree with large, oblong, irregular, pubescent leaves; in young plants the leaves usually palmately lobed; flower large, solitary; capsules large, up to 15 centimeters long, sharply five-angled; seeds winged; in second-growth forests throughout the Philippines.

Pterospermum diversifolium bast is pinkish cinnamon; the fiber strips average 3 millimeters wide and 0.54 millimeter thick. Rope made from it is very low in tensile strength and in breaking length, and because of its brittleness is not commonly used by Filipinos for rope making. Wetting does not affect its tensile strength. All of the dry, and one of the wet, test specimens failed in eye-splices. The values for the tensile strength given by the wet specimens show better agreement than those yielded by the dry ones, the maximum variations from the means in the dry and the wet series being 14 and 8 per cent, respectively.

A summary of the tests made in the Bureau of Science is given in Table XII.

TABLE XII.—*Physical tests of rope made from the bast of Pterospermum diversifolium.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	6.7
Inches	0.26
Mean perimeter, or girth:	
Millimeters	21
Inches	0.83
True mean sectional area:	
Square millimeters	28.8
Square inches	0.044
Ultimate tensile strength (dry):	
Mean in kilograms	75.7
Maximum in kilograms	81.6
Minimum in kilograms	65.3
Mean in pounds	167
Maximum in pounds	180
Minimum in pounds	144
Ultimate tensile strength (wet):	
Mean in kilograms	75.3
Maximum in kilograms	81.2
Minimum in kilograms	70.3
Mean in pounds	166
Maximum in pounds	179
Minimum in pounds	155

TABLE XII.—*Physical tests of rope made from the bast of Pterospermum diversifolium*—Continued.

Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	263
Pounds per square inch	3,740
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	261
Pounds per square inch	3,690
Mean elongation at instant of rupture:	
Dry (per cent)	11
Wet (per cent)	15
Mean weight per unit length:	
Grams per meter	28.9
Pounds per foot	0.0194
Average breaking length:	
Meters	2,620
Feet	8,620
Moisture (per cent)	9.68

PTEROCYMBIUM TINCTORIUM (Blanco) Merr. Talúto.

Local names: *Abigon, taóto, taútu* (Bataan, Leyte); *abigón* (Bataan); *balulau* (Agusan); *bañgat* (Zambales); *bayau, takung* (Surigao); *duidui* or *duyduy* (Tayabas); *huligano* (Nueva Ecija); *libtúk* (Cagayan Province); *malasapsáp* (Pampanga); *marakapas* (Ilocano); *tagung-túñgan* (Cebu); *takong* (Surigao); *talóto* or *talúto* (Bataan, Camarines, Cotabato, Laguna, Mindoro, Negros, Nueva Ecija, Palawan, Tayabas).

A deciduous tree with broadly ovate, often lobed leaves; flowers appearing with or before the new leaves; fruit with a long boat-shaped appendage; throughout the Philippines at low and medium altitudes.

Pterocymbium tinctorium bast is pale yellow-orange. Each strand of the rope averages nine ribbons thick, and these vary in thickness from 0.28 to 0.89 millimeter and have a mean length of 1,889 millimeters. Dry rope made of this bast is low in tensile strength and breaking length. Immersion in water for twenty-four hours increased the tenacity of the fiber about 7 per cent. Wetting also caused the test specimens to break more uniformly. The maximum variation from the mean in the wet series of five tests was 18 per cent, whereas the corresponding value for the five dry specimens was 26 per cent. None of the test pieces saturated with water failed in eye-splices, but three out of the five dry specimens ruptured therein. One of the three specimens that ruptured in an eye-splice gave the maximum result.

A summary of the tests made in the Bureau of Science is given in Table XIII.

TABLE XIII.—*Physical tests of rope made from the bast of Pterocymbium tinctorium.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	13.4
Inches	0.53
Mean perimeter, or girth:	
Millimeters	42
Inches	1.66
True mean sectional area:	
Square millimeters	114.0
Square inches	0.177
Ultimate tensile strength (dry):	
Mean in kilograms	435
Maximum in kilograms	531
Minimum in kilograms	322
Mean in pounds	959
Maximum in pounds	1,170
Minimum in pounds	710
Ultimate tensile strength (wet):	
Mean in kilograms	496
Maximum in kilograms	587
Minimum in kilograms	424
Mean in pounds	1,093
Maximum in pounds	1,295
Minimum in pounds	935
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	381
Pounds per square inch	5,420
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	435
Pounds per square inch	6,180
Mean elongation at instant of rupture:	
Dry (per cent)	10
Wet (per cent)	12
Mean weight per unit length:	
Grams per meter	95.4
Pounds per foot	0.0642
Average breaking length:	
Meters	4,560
Feet	14,900
Moisture (per cent)	11.87

STERCULIA CRASSIRAMEA Merr. Tapinag.

Local names: *Adupong* (Benguet); *balínad* (Palawan, Ticao); *baníkad* (Mindoro); *baníiad* (Guimaras, Mindoro, Rizal); *bannakalau* or *baniakalaw* (Abra, Benguet, Ilocos Norte, Ilocos Sur); *kalukalumpáñgan* (Rizal); *malakapai, malapapaya, tapinag* (Bataan); *palak-palak* (Bulacan).

A large deciduous tree with broadly ovate, cordate, entire, densely pubescent leaves; ample panicles of small flowers; and inflated capsules containing few seeds; ultimate branchlets much thickened; widely distributed in the forested areas of Luzon.

Sterculia crassiramea bast makes a rope which when dry has a medium tensile strength and breaking length. Wetting decreases the tensile strength about 23 per cent. The dry specimens gave uniform breaks with a maximum variation from the mean of 8 per cent. Only one test piece in the series of five dry specimens failed in an eye-splice, and the value given by this specimen is not the minimum. Whereas the tensile-strength results obtained from the dry test pieces show a maximum variation from the mean of only 7 per cent, the wet ones show a maximum variation of 16 per cent from the average. Three out of the five specimens failed in eye-splices.

The strands of the rope tested average six strips of bast thick. These strips vary from 5 to 15 millimeters in width and from 0.31 to 1.04 millimeters in thickness, and their mean length is 1,890 millimeters. The residents of Disdis state that this fiber is readily attacked by an insect called "bucbuc," which quickly destroys the rope by honeycombing it. Experience has shown that all bast-fiber ropes are extraordinarily susceptible to attack by insects and molds. Molds grow luxuriantly on these fibers if they are allowed to remain exposed, particularly during rainy and damp weather. The molds discolor the bast and in some cases permanently stain it by the secretion of pigments. It was necessary to preserve the museum specimens of bast rope in a large covered glass jar containing a wad of cotton saturated with formalin, in order to inhibit the growth of fungi and to prevent the attack of insects.

A summary of the tests made in the Bureau of Science is given in Table XIV.

TABLE XIV.—*Physical tests of rope made from the bast of Sterculia crassiramea.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	12.7
Inches	0.50
Mean perimeter, or girth:	
Millimeters	40
Inches	1.58
True mean sectional area:	
Square millimeters	121.3
Square inches	0.188

TABLE XIV.—*Physical tests of rope made from the bast of Sterculia crassiramea*—Continued.

Ultimate tensile strength (dry):	
Mean in kilograms	483
Maximum in kilograms	503
Minimum in kilograms	446
Mean in pounds	1,064
Maximum in pounds	1,110
Minimum in pounds	985
Ultimate tensile strength (wet):	
Mean in kilograms	373
Maximum in kilograms	435
Minimum in kilograms	315
Mean in pounds	823
Maximum in pounds	960
Minimum in pounds	695
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	398
Pounds per square inch	5,660
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	308
Pounds per square inch	4,380
Mean elongation at instant of rupture:	
Dry (per cent)	13
Wet (per cent)	14
Mean weight per unit length:	
Grams per meter	95.5
Pounds per foot	0.0642
Average breaking length:	
Meters	5,050
Feet	16,600
Moisture (per cent)	11.65

STERCULIA FOETIDA Linn. Kalumpáng.

Local names: *Bañgar* (Ilocano, Itneg); *bóbog, bo-bog, bubog, bobo* (Balabac, Iloilo, Negros, Palawan, Panay); *boñgog* (Cagayan); *bubur, bobor* (Ilocos Sur); *kalumpáng* (Apo Island, Bataan, Camarines, Cotabato, Iloilo, Laguna, Manila, Mindoro, Nueva Ecija, Palawan, Pampanga, Polillo, Rizal, Tayabas).

A large tree with palmately five-foliate leaves, the leaflets oblong-lanceolate, acuminate, entire, glabrous; flowers very fetid; capsules very large, bright red when mature, obovoid, splitting down one side, the oblong edible seeds persistent for some time after maturity; common and widely distributed in the Philippines.

With the exception of two other basts, *Sterculia foetida* is the weakest fiber tested. Immersion in water for twenty-four hours does not affect its tensile strength. The extremely low tenacity of this bast, together with its comparative scarcity, limit its usefulness as a cordage fiber.

Sterculia foetida bast is light salmon-orange. The strands of the rope tested are eight strips thick, and the latter average 4 millimeters wide, 0.30 millimeter thick, and 767 millimeters long. None of the five dry specimens ruptured in eye-splices; and the tensile-strength values are in close agreement, the maximum variation from the mean being only 4 per cent. Of the four wet specimens broken one failed in an eye-splice, giving the minimum value. There was a wide variation in the tensile strength of the wetted pieces, the maximum from the mean value being 28 per cent.

A summary of the tests made of this species in the Bureau of Science is given in Table XV.

TABLE XV.—*Physical tests of rope made from the bast of Sterculia foetida.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	7.0
Inches	0.28
Mean perimeter, or girth:	
Millimeters	22
Inches	0.87
True mean sectional area:	
Square millimeters	28.4
Square inches	0.044
Ultimate tensile strength (dry):	
Mean in kilograms	56.7
Maximum in kilograms	58.9
Minimum in kilograms	54.9
Mean in pounds	125
Maximum in pounds	130
Minimum in pounds	120
Ultimate tensile strength (wet):	
Mean in kilograms	56.7
Maximum in kilograms	72.5
Minimum in kilograms	48.1
Mean in pounds	125
Maximum in pounds	160
Minimum in pounds	106
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	200
Pounds per square inch	2,840
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	200
Pounds per square inch	2,840
Mean elongation at instant of rupture:	
Dry (per cent)	6
Wet (per cent)	10

TABLE XV.—*Physical tests of rope made from the bast of Sterculia foetida*—Continued.

Mean weight per unit length:	
Grams per meter	28.8
Pounds per foot	0.0194
Average breaking length:	
Meters	1,964
Feet	6,450
Moisture (per cent)	8.88

STERCULIA OBLONGATA R. Br. Malaboho.

Local names: *Bakan* (Mindoro); *banabá* (Ilocos Norte); *banílad* (Mindoro, Rizal); *búñga, malabúñga* (Tayabas); *hantak* (Batanes); *lapnít* (Calayan, Babuyanes); *malabóho* (Bataan); *malakakao* (Bataan, Laguna); *malabanilad* (Samar); *sinaligan* (Abra, Benguet); *nós* (Camarines).

A small or medium-sized tree with oblong, glabrous, entire leaves; terminal panicles of small flowers; and oblong, bright red, inflated capsules; widely distributed in the Philippines at low altitudes.

Most of the strips of *Sterculia oblongata* are salmon-buff, some are tawny, and others are salmon-orange. Each strand of the rope is from six to eight strips thick. Some strips are only 2 millimeters wide and 0.13 millimeter thick, and others are 14 millimeters wide and 0.77 millimeter thick; all are marked longitudinally with narrow elongated depressions that give them a grained surface not unlike wood. Some of the depressions extend through the bast.

Tests show that rope made of *Sterculia oblongata* bast when dry possesses only medium tensile strength and breaking length When wetted, the strength is markedly decreased; the mean tensile strength of specimens saturated with water showed an average reduction of 27 per cent. The tests indicate that rope made of this bast is not suited for use in water. However, the information obtained in the field is quite the contrary. The residents of Disdis, Benguet, state that rope made of *Sterculia oblongata* bast is preferably used during the rainy season. Two of the five dry, and three of the five wet, test specimens failed in eye-splices, the maximum and minimum values in both series of tests being obtained from specimens that ruptured outside of eye-splices. The maximum variations from the mean tensile strength in the dry and the wet series were 9 and 17 per cent, respectively.

A summary of the tests of this species made in the Bureau of Science is given in Table XVI.

TABLE XVI.—*Physical tests of rope made from the bast of Sterculia oblongata.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	12.1
Inches	0.48
Mean perimeter, or girth:	
Millimeters	38
Inches	1.50
True mean sectional area:	
Square millimeters	96.0
Square inches	0.149
Ultimate tensile strength (dry):	
Mean in kilograms	382
Maximum in kilograms	413
Minimum in kilograms	351
Mean in pounds	842
Maximum in pounds	920
Minimum in pounds	775
Ultimate tensile strength (wet):	
Mean in kilograms	279
Maximum in kilograms	327
Minimum in kilograms	241
Mean in pounds	615
Maximum in pounds	720
Minimum in pounds	530
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	398
Pounds per square inch	5,650
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	291
Pounds per square inch	4,130
Mean elongation at instant of rupture:	
Dry (per cent)	13
Wet (per cent)	14
Mean weight per unit length:	
Grams per meter	85.1
Pounds per foot	0.0572
Average breaking length:	
Meters	4,490
Feet	14,700
Moisture (per cent)	13.05

STERCULIA STIPULARIS R. Br. Bonotan.

Local names: *Bisong* (Nueva Vizcaya); *bonotan, rapok* (Ilocos Norte); *buñgat* (Cagayan); *labnai* (Abra, Itneg); *malagasáha* (Tayabas).

A medium-sized tree with oblong-ovate, rusty-pubescent, entire, acuminate leaves; flowers numerous, calyx-lobes elongated; capsules red, inflated; widely distributed in the Philippines at low altitudes.

The strips of *Sterculia stipularis* bast are lacelike and present a sievelike appearance. They are uniformly ochraceous buff. Some are 12 millimeters wide, though most of them vary between 4 and 5 millimeters. They are thin, fluctuate between 0.15 millimeter and 0.43 millimeter in thickness, and have a mean length of 980 millimeters. The strands of the rope are eight strips thick.

When dry, the rope is very low in tensile strength and in breaking length. Wetting raises the tensile strength about 37 per cent. Notwithstanding its low tenacity, the Filipinos frequently use this bast for making rope. They state that it is durable in the wet season. The rope finds special application for making hog traps.

All of the five wet specimens broke in eye-splices, whereas only two of the dry test pieces failed in this manner. The maximum variations from the mean tensile strength in the dry and the wet series were 29 and 22 per cent, respectively.

A summary of the tests of this species made in the Bureau of Science is given in Table XVII.

TABLE XVII.—*Physical tests of rope made from the bast of Sterculia stipularis.*

[Rope made at Dolores, Abra Province.]

Mean diameter:	
Millimeters	7.0
Inches	0.28
Mean perimeter, or girth:	
Millimeters	22
Inches	0.87
True mean sectional area:	
Square millimeters	29.5
Square inches	0.046
Ultimate tensile strength (dry):	
Mean in kilograms	79.4
Maximum in kilograms	102
Minimum in kilograms	59.4
Mean in pounds	175
Maximum in pounds	225
Minimum in pounds	131
Ultimate tensile strength (wet):	
Mean in kilograms	108
Maximum in kilograms	136
Minimum in kilograms	84.8
Mean in pounds	239
Maximum in pounds	299
Minimum in pounds	187

TABLE XVII.—*Physical tests of rope made from the bast of Sterculia stipularis*—Continued.

Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	268
Pounds per square inch	3,800
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	366
Pounds per square inch	5,200
Mean elongation at instant of rupture:	
Dry (per cent)	7
Wet (per cent)	10
Mean weight per unit length:	
Grams per meter	26.6
Pounds per foot	0.0179
Average breaking length:	
Meters	2,980
Feet	9,780
Moisture (per cent)	8.26

MALVACEAE

BOMBYCIDENDRON VIDALIANUM Merr. and Rolfe. Lanutan.

Local names: *Lanótan* (Bulacan); *lanútan* (northern Luzon to Bulacan and Bataan); *losóban* (Abra); *lusúban, lusóban* (Ilocano, Itneg); *pañgardísen* (Cagayan, Ilocos Sur); *takúlau-blanco* (Ilocos Norte).

A medium-sized tree with oblong-lanceolate, acuminate leaves and large white flowers; capsules ovoid; widely distributed in Luzon at low altitudes.

The strands of the rope made of *Bombycidendron vidalianum* bast average sixteen strips thick, the latter varying in width from 2 to 8 millimeters, and in thickness from 0.13 to 0.31 millimeter. The dry rope possesses a high tensile strength and breaking length. Immersion in fresh water reduces the mean tensile strength by about 26 per cent. The Ilocanos consider this bast to be pliable, resistant, and durable, and fitted for service throughout the year. The tensile-strength tests showed an erratic tendency, the wet specimens showing poorer agreement than the dry ones. In the dry series of five tests the maximum variation from the mean tensile strength was 18 per cent, and that from the average value in the five wet specimens was 30 per cent. Four of the five dry, and three of the five wet, specimens ruptured outside of eye-splices, the other test pieces breaking in splices. In both series of tests the minimum values were given by specimens breaking in the unspliced portion of the rope.

A summary of the results of tests of *Bombycidendron vidalianum* bast rope made at the Bureau of Science are given in Table XVIII.

TABLE XVIII.—*Physical tests of rope made from the bast of Bombycidendron vidalianum.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	7.0
Inches	0.28
Mean perimeter, or girth:	
Millimeters	22
Inches	0.87
True mean sectional area:	
Square millimeters	31.6
Square inches	0.049
Ultimate tensile strength (dry):	
Mean in kilograms	199
Maximum in kilograms	223
Minimum in kilograms	175
Mean in pounds	438
Maximum in pounds	515
Minimum in pounds	386
Ultimate tensile strength (wet):	
Mean in kilograms	148
Maximum in kilograms	176
Minimum in kilograms	103
Mean in pounds	327
Maximum in pounds	389
Minimum in pounds	226
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	630
Pounds per square inch	8,940
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	468
Pounds per square inch	6,670
Mean elongation at instant of rupture:	
Dry (per cent)	12
Wet (per cent)	14
Mean weight per unit length:	
Grams per meter	28.6
Pounds per foot	0.0192
Average breaking length:	
Meters	6,950
Feet	22,800
Moisture (per cent)	8.56

MALACHRA FASCIATA Jack. Páang-balíwis.

Local names: *Annabo* (Union); *bakembákes* (Ilocano, Itneg); *malabitíspapa* (Bataan); *páang balíwis* (Manila and vicinity, Tagalog, Pangasinan).

A coarse, suffrutescent, weedy herb, introduced from tropical America, with coarsely hairy, palmately lobed leaves and axillary pink flowers; in and about towns as a weed in waste places at low altitudes; locally very abundant.

Unlike most of the bast tested in the form of rope, *Malachra fasciata* bast has more of a filamentous than a ribbon character due to the fact that the fiber is prepared by retting. The entire bush is cut and then steeped in fresh water for about ten days, at the end of which time the bast is easily stripped and washed free of the larger portion of nonfibrous material. Plate III, fig. 13, illustrates the filamentous nature of this bast; bundles instead of strips would be the more correct designation of the fiber elements constituting the strands. These bundles of filaments vary from fine hairlike fibrils with elliptical cross section to coarse polygonal bundles calipering about 0.76 millimeter in thickness. A few of the bundles are ribbon-shaped but narrow, and in no case exceed 2 millimeters in width. They have an average thickness of 0.46 millimeter. The strands are, roughly, ten bast bundles thick. *Malachra fasciata* bast is olive buff; owing to its nonstaining property, rope made from it is said to be used for hanging clothes in addition to serving as a general utility rope.

The dry rope has an excellent tensile strength and breaking length. Wetting decreases the mean tensile strength 15 per cent and also causes the specimens to break more uniformly. The maximum variation from the mean tensile strength in the five wetted specimens was only 6 per cent, whereas the maximum difference from the average value in the dry ones was 20 per cent. One of the wet, and two of the dry, test pieces were ruptured in eye-splices.

A summary of the tests of this species made in the Bureau of Science is given in Table XIX.

TABLE XIX.—*Physical tests of rope made from the bast of Malachra fasciata.*

[Rope made at Dolores, Abra Province.]

Mean diameter:	
Millimeters	5.4
Inches	0.21
Mean perimeter, or girth:	
Millimeters	17
Inches	0.67
True mean sectional area:	
Square millimeters	21.2
Square inches	0.033
Ultimate tensile strength (dry):	
Mean in kilograms	135
Maximum in kilograms	152
Minimum in kilograms	108
Mean in pounds	298
Maximum in pounds	335
Minimum in pounds	239

TABLE XIX.—*Physical tests of rope made from the bast of Malachra fasciata*—Continued.

Ultimate tensile strength (wet):	
Mean in kilograms	115
Maximum in kilograms	122
Minimum in kilograms	109
Mean in pounds	253
Maximum in pounds	268
Minimum in pounds	240
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	637
Pounds per square inch	9,030
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	543
Pounds per square inch	7,700
Mean elongation at instant of rupture:	
Dry (per cent)	8
Wet (per cent)	10
Mean weight per unit length:	
Grams per meter	17.9
Pounds per foot	0.0120
Average breaking length:	
Meters	7,580
Feet	24,800
Moisture (per cent)	848

SIDA ACUTA Burm.

Local names: *Attái-na-baka* (Ibanak); *basbasot* (Bontoc); *eskobilla* (Visayan); *eskuba* Davao); *eskubilla* (Laguna); *herbaka* (Ilocos Sur); *kastule* (Tagalog, Bulacan); *maratakkimbaka* (Ilocano in Tarlac); *salike* (Visayan, Basilan); *takkimbaka* (Abra, Ilocos Norte, Isabela, Pangasinan, Union); *takkinbaka, ualis-ualisan* (Tarlac); *uaualisin* (Bulacan); *ualis-ualisan* (Nueva Vizcaya); *ualis-ualisan* (Manila).

A slender, sparingly branched, shrubby or suffrutescent plant, a meter high or less, with elongated slender branches and lanceolate, glabrous, acuminate leaves; flowers yellow, axillary, short-pedicelled; in waste places in and about towns throughout the Philippines; abundant.

Species of *Sida* have been reported as common jungle plants in India,[23] but long-staple fiber is produced only by plants grown on well-drained land with plenty of moisture. In India (and this applies to the Philippines with greater force) there are difficulties still to be solved before any of the species of *Sida* can be cultivated profitably. Watt states:[24]

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[23] Agr. Journ. India 4 (1909) 351.

[24] Watt, Geo., A Dictionary of the Economic Products of India. Government of India Central Printing Office, Calcutta 6^{2} (1893) 683.

> * * * But the utilization of Sida will mainly depend on the particular form that will produce the tallest stems with the fewest branches, and the highest percentage of fibre to weight of stems. It may readily be admitted that the feature, on which the industry will fail to be established, will be the yield as compared with jute. Hitherto the few Reports that have appeared exhibit the yield as considerably lower than that of jute. Experimenters should, however, not be too easily disheartened on this score, for it must be borne in mind that Sida has never been systematically cultivated, while everything has been done that is possible to improve the yield and quality of jute. * * *

Sida fiber has been reported as weaker than jute, *Corchorus olitorius;*[25] the results obtained in this investigation also show that *Sida acuta* bast is less resistant than jute. *Sida* fiber is said to spin well, and it can be mixed with other fibers that are at present used on a manufacturing scale.

Sida acuta bast is one of the prettiest fibers tested. It is marguerite yellow, fine, filamentous, soft, lustrous, and silky. The particular sample had been retted for about ten days in fresh water and subsequently cleaned, so that its preparation is quite different from that of most of the other fibers tested. The fine filaments still held together slightly in bundles similar to the original ribbonlike form. Practically all of the gum and pulp had been removed by the retting and subsequent washing, making the fiber very pliable and altogether unlike the crude, harsh, and stiff strips characteristic of most of the other ropes tested.

Although *Sida acuta* makes a handsome, silky looking rope, it possesses only medium tensile strength and breaking length. Wetting increases its mean tensile strength about 6 per cent. The wet series of tests gave better agreement than the dry, the maximum difference from the mean tensile strength in the former being 7 per cent and in the latter 12 per cent. Three of the five dry specimens and three of the four wet test pieces failed in eye-splices. The Ilocanos consider rope made of *Sida acuta* a superior product because of its durability under both dry and wet conditions, its pleasing color, and its gloss. It is used for general purposes and is particularly suited for use where a nonstaining fiber is desired.

A summary of the tests of this species made in the Bureau of Science is given in Table XX.

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[25] Bull. Imp. Inst. 10 (1912) 218.

TABLE XX.—*Physical tests of rope made from the bast of Sida acuta.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	7.6
Inches	0.30
Mean perimeter, or girth:	
Millimeters	24
Inches	0.95
True mean sectional area:	
Square millimeters	40.8
Square inches	0.063
Ultimate tensile strength (dry):	
Mean in kilograms	193
Maximum in kilograms	216
Minimum in kilograms	162
Mean in pounds	426
Maximum in pounds	476
Minimum in pounds	357
Ultimate tensile strength (wet):	
Mean in kilograms	205
Maximum in kilograms	213
Minimum in kilograms	190
Mean in pounds	453
Maximum in pounds	470
Minimum in pounds	418
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	475
Pounds per square inch	6,760
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	502
Pounds per square inch	7,190
Mean elongation at instant of rupture:	
Dry (per cent)	14
Wet (per cent)	18
Mean weight per unit length:	
Grams per meter	33.5
Pounds per foot	0.0225
Average breaking length:	
Meters	5,770
Feet	18,900
Moisture (per cent)	8.67

THESPESIA LAMPAS (Cav.) Dalz. & Gib. Marakapas.

Local names: *Amagóng* (Nueva Ecija); *bulakbulákan* (Tagalog); *dal-dal-upang* (Ilocano, Itneg); *kapas-kápas* (Union); *kastule* (Tagalog); *kastuli* (Rizal); *makakápas* (Zambales); *marakápas* (Abra, Amburayan); *maratarong* (Abra, Ilocano, Itneg).

An erect, slightly branched shrub, 2 to 3 meters high, with broadly ovate, usually three-lobed, leaves; flowers large, 6 to 8 centimeters long, yellow with a deep purple center, capsule ovoid, about 3 centimeters long, four- or five-valved; widely scattered in the settled areas of the Philippines at low altitudes.

The strips of *Thespesia lampas* bast composing this sample of rope are streaky cream, and average 0.51 millimeter thick, 5 millimeters wide, and 1,203 millimeters long. Each strand averages sixteen strips thick. Due to the large amount of woody material the strips of crude bast are stiff and hard. After exposure to the laboratory air for a day or so during the rainy season the fiber was covered with a growth of gray mold. Nearly all of the crude basts are susceptible to molds, but *Thespesia lampas* is apparently more readily infested than are the others. Retted fibers, like *Sida acuta* and *Abroma fastuosa*, are attacked little, if at all, when properly cleaned.

Rope made of this bast when dry is very low in tensile strength and in breaking length. The wetted specimens were about 8 per cent more tenacious than the dry test pieces. Both gave erratic results, the maximum differences from the mean tensile strength being 24 and 21 per cent, respectively. Two of the five dry, and four of the five wet, specimens ruptured in the unspliced sections of the test pieces, the remaining ones breaking in eye-splices. The minimum values in both the dry and the wet series were obtained from specimens that failed outside of eye-splices, whereas the maximum values in the respective series were given by test pieces ruptured in eye-splices.

A summary of the tests of this species made in the Bureau of Science is given in Table XXI.

TABLE XXI.—*Physical tests of rope made from the bast of Thespesia lampas.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	9.6
Inches	0.38
Mean perimeter, or girth:	
Millimeters	30
Inches	1.18
True mean sectional area:	
Square millimeters	57.8
Square inches	0.09
Ultimate tensile strength (dry):	
Mean in kilograms	155
Maximum in kilograms	192
Minimum in kilograms	121
Mean in pounds	341
Maximum in pounds	424
Minimum in pounds	267

TABLE XXI.—*Phsiycal tests of rope made from the bast of Thespesia lampas*—Continued.

Ultimate tensile strength (wet):	
Mean in kilograms	168
Maximum in kilograms	191
Minimum in kilograms	133
Mean in pounds	370
Maximum in pounds	421
Minimum in pounds	293
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	268
Pounds per square inch	3,800
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	291
Pounds per square inch	4,130
Mean elongation at instant of rupture:	
Dry (per cent)	9
Wet (per cent)	13
Mean weight per unit length:	
Grams per meter	48.7
Pounds per foot	0.0327
Average breaking length:	
Meters	3,180
Feet	10,400
Moisture (per cent)	8.22

URENA LOBATA Linn. Kollokollot.

Local names: *Afulut* (Gaddanes in Nueva Vizcaya); *anonongkot* (Bicol); *dalupang* (Visayan, Culion); *kol-lokollót* (Amburayan, Ilocos Sur, Nueva Vizcaya, Pangasinan, Tarlac); *kollolót* (Abra); *kolot-kolótan, kulut-kulútan* (Pampango, Tagalog, Visayan); *kulat-kulát* (Pangasinan); *kullu-kullúk* (Ilocano in Isabela); *kuluk* (Ibanak); *kulu-kulót* (Bontoc); *kulut-kulútang, dalupang* (Negros); *mangkit* (Tayabas); *puot-sinúang* (Isinai in Nueva Vizcaya); *puriket* (Abra).

An erect, branched, shrubby plant, 0.5 to 2 meters high, with ovate to orbicular, usually lobed, leaves; pink flowers; and small, globose, shiny fruits; a weed in the settled areas throughout the Philippines; abundant.

In India (Assam and Burma) *Urena lobata*, which is said to grow sometimes 8 feet high, is used as a cordage material. It is a fiber of the jute type and is said to be more easily extracted than jute. *Urena lobata* is one of the three important textile fibers known to the natives of Madagascar.[26] They make rope, twine, and mats from the bast. In the manufacture of coffee bags it is said to be an excellent substitute for jute because the fiber has no influence on the aroma of the coffee.[27]

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[26] Der Tropenpflanzer 7 (1903) 451.

[27] The Useful Plants of Nigeria, Part 1 *Kew Bull.* add. ser. IX Part 1 (1908) 68–69.

The bark is used in Yoruba and Angola for making ropes, and also as a tying material in house building. When thoroughly cleaned the fiber is said[28] to be fine, white, and a meter in length, and to take color well. It is strong and makes good cordage. Experiments have also been conducted to determine its suitability for use as a paper stock, and it was found to be almost twice as strong as Bank of England note pulp. In another place a sample of this fiber from India[29] is reported as having uneven strength, and as having a filament length of from 7 to 9 feet. This particular sample of fiber was of good spinning quality, and could be spun in conjunction with the finest grades of Calcutta jute.

Numerous references[30] are found in the literature regarding the use, cultivation, and extraction of *Urena lobata* bast, and its possibilities as a substitute for jute. The most extensive attempts to extract this fiber on a large scale (and at the same time the most costly and perhaps most disastrous) were made in Brazil where the bast is commonly known as "aramina." In this connection the British Consul at Santos, Brazil, reports:[31]

> It was thought that a substitute for jute had been discovered in the aramina plant which grows wild, but under cultivation it lost a great part of the fibrous nature, and as the supply of the wild plant was wholly insufficient, a mill put up at a cost of some £24,000 [240,000 pesos] had to be shut down and after undergoing the necessary transformation is now used for the manufacture of hessians.

Unfortunately the sample of rope procured at Dolores, Abra, as having been made of *Urena lobata* was made of a mixture of *Corchorus olitorius* (jute) and *Urena lobata* basts, in about equal proportions. Apparently the manufacturer discovered that he would not have enough of the latter fiber to make the length of rope ordered, and he, therefore, made up the deficiency by using *Corchorus olitorius* bast, which is plentiful in the region and which has properties similar to those possessed by *Urena lobata*. The strips of *Urena lobata* bast used in the rope were cream buff and averaged about 2 millimeters wide, 0.41 millimeter thick, and 1,118 millimeters long. The strips of *Corchorus olitorius* that were mixed in were mahogany red on the outer face and pinkish cinnamon on the inner. The strands of the rope spun were about eight strips thick.

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[28] Agr. Bull. Straits & Fed. Malay States, IV, n. s. 6 (1905).

[29] Bull. Imp. Inst. 12 (1914) 34 and 35.

[30] Abbey and Yates, Agr. Ledger 15 (1908–09) 51–62. This paper gives some sixty references.

[31] Agr. Ledger 15 (1908–09) 57. [Apparently taken from the report of H. B. M. Consul at Santos, Brazil, appearing in the Board of Trade Journal 62 (1908) 91.]

When dry, the rope gives a medium tensile strength and breaking length. Rope made entirely of *Corchorus olitorius* gives about the same values. Wetting the rope made of the mixture of the two fibers decreases the mean tensile strength 24 per cent, and that made of jute is reduced 28 per cent. The tensile-strength values given by the five dry specimens showed much variation, the maximum from the mean being 34 per cent, but the five wet test pieces gave more concordant results, the maximum variation being only 11 per cent. Four of the dry, and two of the wet, test pieces failed in eye-splices. The Filipinos consider *Urena lobata* fiber to be fairly tenacious, but they say that it is not suitable for wet-weather use since it is unduly weakened when wetted and, besides, undergoes rapid deterioration.

A summary of the tests made in the Bureau of Science is given in Tables XXII and XXIV and shows that *Urena lobata* and *Corchorus olitorius* basts have similar properties.

TABLE XXII.—*Physical tests of rope made from the bast of Urena lobata.*

[Rope made at Dolores, Abra Province. This sample was made of a mixture of *Urena lobata* and *Corchorus olitorius* in about equal parts.]

Mean diameter:	
Millimeters	6.7
Inches	0.26
Mean perimeter, or girth:	
Millimeters	21
Inches	0.83
True mean sectional area:	
Square millimeters	32.3
Square inches	0.047
Ultimate tensile strength (dry):	
Mean in kilograms	146
Maximum in kilograms	195
Minimum in kilograms	120
Mean in pounds	322
Maximum in pounds	430
Minimum in pounds	264
Ultimate tensile strength (wet):	
Mean in kilograms	111
Maximum in kilograms	122
Minimum in kilograms	99.3
Mean in pounds	244
Maximum in pounds	270
Minimum in pounds	219

TABLE XXII.—*Physical tests of rope made from the bast of Urena lobata*—Continued.

Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	482
Pounds per square inch	6,850
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	366
Pounds per square inch	5,200
Mean elongation at instant of rupture:	
Dry (per cent)	8
Wet (per cent)	11
Mean weight per unit length:	
Grams per meter	23.7
Pounds per foot	0.0159
Average breaking length:	
Meters	6,180
Feet	20,300
Moisture (per cent)	9.78

TILIACEAE

COLUMBIA BLANCOI Rolfe. Anilau.

Local names: *Aniláu, mamadlíng, mamauéd* (Rizal); *keddéng* (Ilocano, Benguet).

A small tree, attaining a height of about 10 meters, with oblong-ovate, acuminate, toothed, hairy leaves, 10 to 20 centimeters long, their bases obliquely cordate; panicles terminal, many-flowered, flowers usually pink; capsules about 1 centimeter long, 3- or 4-winged, obovoid; throughout the Philippines at low and medium altitudes; common.

Columbia blancoi bast strips are salmon buff; they average 0.65 millimeter thick and vary from 2 to 13 millimeters in width. The strands average nine strips thick.

Dry rope made of this bast gives a very low tensile strength and breaking length. Wetting the rope increases the mean tensile strength about 1 per cent and also gives more concordant results. The maximum variation from the mean tensile strength in five tests of the dry rope was 16 per cent, while that shown by the five tests of wet specimens was 10 per cent. The inhabitants of Disdis, Benguet, who made the rope state that it is preferably used during wet weather on account of its durability when wetted. Two of the dry, and two of the wet, specimens broke in eye-splices.

A summary of the tests of this species made in the Bureau of Science is given in Table XXIII.

TABLE XXIII.—*Physical tests of rope made from the bast of Columbia blancoi.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	13.7
Inches	0.54
Mean perimeter, or girth:	
Millimeters	43
Inches	1.69
True mean sectional area:	
Square millimeters	115.2
Square inches	0.179
Ultimate tensile strength (dry):	
Mean in kilograms	347
Maximum in kilograms	402
Minimum in kilograms	281
Mean in pounds	765
Maximum in pounds	885
Minimum in pounds	620
Ultimate tensile strength (wet):	
Mean in kilograms	352
Maximum in kilograms	376
Minimum in kilograms	315
Mean in pounds	776
Maximum in pounds	830
Minimum in pounds	695
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	302
Pounds per square inch	4,270
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	306
Pounds per square inch	4,340
Mean elongation at instant of rupture:	
Dry (per cent)	13
Wet (per cent)	15
Mean weight per unit length:	
Grams per meter	98.7
Pounds per foot	0.0663
Average breaking length:	
Meters	3,510
Feet	11,500
Moisture (per cent)	11.96

CORCHORUS OLITORIUS Linn. Saluyut or Jute.

Common names: Calcutta flax, gunny, Indian grass, Jew's mallow, jute, melochia (English); *chanvre de Calcutta, fil de jute, jute, mauve de juif* (French); *Bengalhanf, Gemüsepappel, indischer Flachs, Judenhanf, Judenpappel, Jute, Kalkuttanhanf, Meluchia, Muskraut, Paathanf* (German); *yute* (Spanish).

Local names: *Pasau* (Tagalog), Zambales); *salúyot, salúyut* or *salóyot* (Ilocos Sur, Pangasinan, Union); *tagabang* (Visayan, Manila); *taka magindánau, yaka* (Cotabato).

An erect, glabrous, branched, suffrutescent herb, 1 to 1.5 meters high, the ovate-lanceolate leaves tailed at the base; flowers small, yellow, axillary; capsules cylindric, 10-ribbed, 3 to 3.5 centimeters long; a weed in damp places throughout the settled areas of the Philippines.

Corchorus olitorius is an annual herb that grows wild in nearly all islands of the Philippines. It is indigenous to India, where together with a closely related species, *Corchorus capsularis* Linn., it is cultivated on a large scale to furnish most of the jute of commerce. The plant is found in all tropical countries; but it is only in India, where next to rice it is the most important agricultural product, that the fiber is extracted in commercial quantities. In the Philippines, particularly among the Ilocanos, it is better known as a vegetable than as a source of fiber. The leaves and the tender shoots are stewed with *bagoong* (salty, fermented small fish or shrimp), cooked with bamboo shoots, or roasted or baked with fish. Among the Tagalogs the leaves are sold in the market with the name "pasau." In Sierra Leone, Nigeria, and Uganda parts of the plant are eaten as a vegetable. The plant is cultivated as a garden herb in France, and the tender shoots are used in salads.

Corchorus olitorius was known to the ancients. Watt states:[32]

> * * * It is well known that *Corchorus olitorius* has for centuries been cultivated near Aleppo as a pot herb, hence, says Rauwolf, the name *Olus judaicum* which the French translated *Mauve de Juif* and the English rendered as Jew's Mallow.

In India the total area under jute cultivation in 1916 was 2,702,700 acres, and the yearly exports[33] of Indian jute during the past two decades have been valued at more than 100,000,000 pesos. Of sacks alone more than 100,000,000 are exported annually, having a value of at least 14,000,000 pesos.

In the Philippines the fiber has no commercial importance, but small quantities are extracted for the manufacture of rope. Such cordage as a rule does not reach the market, but is used locally.

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[32] Watt, Geo., A Dictionary of the Economic Products of India. Government of India Central Printing Office, Calcutta 2 (1889) 542.

[33] Agr. Journ. India III 13 (1918) 500. The export of raw jute and manufactures from India is given as follows:

	1915–16	1916–17
	£	£
Raw jute	10,428,024	10,858,736
Jute manufactures	25,318,934	27,769,725

Comparatively speaking, jute as it occurs in commerce is a very inferior fiber; in fact, it is the cheapest fiber used in the United States. It is only because of the facility with which it is cultivated, together with its adaptability for spinning, that it has such great importance in the present industrial economy. The fiber, which is initially relatively weak, soon deteriorates under the influence of moisture. It is produced in greater quantities than any other fiber except cotton and sisal and is principally used for making the burlap employed in the manufacture of gunny sacks. Jute is also used in the manufacture of cordage, twine, carpets, rugs, and cheap plushes and velvets. It is sometimes used as a cotton adulterant. Jute butts are excellent material for so-called "linen" paper. Watt states that jute is also used as a substitute for silk.

The fiber constituting the rope tested in this investigation is altogether different from the filamentous jute of commerce, to which reference is always made when speaking of jute in a technical sense. As Plate IV, fig. 3, shows, the fiber here tested is in the form of crude strips of bast that have not been subjected to the retting process and show little if any resemblance to the fiber as it is used in the textile industry.

Each strand of the rope averages eight strips thick. The strips have a mean width of 4 millimeters, vary in thickness from 0.23 to 0.41 millimeter, and average 1,186 millimeters in length. On one side the bast ribbons are mahogany red and on the other pinkish cinnamon, so that the rope has a mottled appearance, as Plate IV, fig. 3, clearly shows.

When dry, rope made of crude *Corchorus olitorius* bast strips has a medium tensile strength and breaking length. Wetting diminishes the tenacity of the fiber considerably. After twenty-four hours' immersion in fresh tap water, the mean tensile strength is reduced 28 per cent. Wetting also induces less concordant strength values. The maximum variation from the mean in the five wet specimens was 18 per cent. The five dry test specimens gave exceptionally good agreement, the maximum variation from the mean being only 7 per cent. Two of the dry, and three of the wet, test pieces failed in eye-splices.

A summary of the tests of this species made in the Bureau of Science is given in Table XXIV.

TABLE XXIV.—*Physical tests of rope made from the bast of Corchorus olitorius.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	7.0
Inches	0.28
Mean perimeter, or girth:	
Millimeters	22
Inches	0.87
True mean sectional area:	
Square millimeters	32.8
Square inches	0.051
Ultimate tensile strength (dry):	
Mean in kilograms	165
Maximum in kilograms	176
Minimum in kilograms	150
Mean in pounds	364
Maximum in pounds	388
Minimum in pounds	344
Ultimate tensile strength (wet):	
Mean in kilograms	118
Maximum in kilograms	139
Minimum in kilograms	97.9
Mean in pounds	260
Maximum in pounds	306
Minimum in pounds	216
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	503
Pounds per square inch	7,130
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	360
Pounds per square inch	5,100
Mean elongation at instant of rupture:	
Dry (per cent)	8
Wet (per cent)	10
Mean weight per unit length:	
Grams per meter	30.5
Pounds per foot	0.0205
Average breaking length:	
Meters	5,420
Feet	17,800
Moisture (per cent)	9.33

GREWIA BILAMELLATA Gagnep. Benglareng.

Local names: *Benglaleng or benglareng* (Ilocano and Itneg); *dongrareng* (Ilocano).

A shrub with oblong, nearly glabrous, green leaves, and small, glabrous, somewhat fleshy fruits; allied to *Grewia multiflora* Juss.

The bast strips constituting the rope tested are cream colored, are softer and thinner than most of the other basts, measure from 0.10 to 0.31 millimeter thick, average 4 millimeters wide, and have a mean length of 1,060 millimeters. The strands average fourteen strips thick.

When dry, rope made of this bast gives a very low tensile strength and breaking length. Wetting the rope causes an extraordinary reduction in tensile strength, amounting to 44 per cent, or nearly half its original strength. The five dry specimens gave more concordant results than the five wet ones, the maximum variations from the mean tensile strength in the two series being 11 and 29 per cent, respectively. None of the wet, and only one of the dry, test pieces ruptured in an eye-splice, and the latter did not give the minimum value. Filipinos say that rope made of this bast is durable during the dry season, but that the fiber quickly deteriorates when wetted. The high loss in strength upon wetting shows that the fiber is suited for use in the dry condition only. This fiber is said to be abundant.

A summary of the tests of this species made in the Bureau of Science is given in Table XXV.

TABLE XXV.—*Physical tests of rope made from the bast of Grewia bilamellata.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	7.6
Inches	0.30
Mean perimeter, or girth:	
Millimeters	24
Inches	0.95
True mean sectional area:	
Square millimeters	38.8
Square inches	0.060
Ultimate tensile strength (dry):	
Mean in kilograms	124
Maximum in kilograms	136
Minimum in kilograms	110
Mean in pounds	274
Maximum in pounds	300
Minimum in pounds	243
Ultimate tensile strength (wet):	
Mean in kilograms	69.8
Maximum in kilograms	85.6
Minimum in kilograms	49.4
Mean in pounds	154
Maximum in pounds	189
Minimum in pounds	109

TABLE XXV.—*Physical tests of rope made from the bast of Grewia bilamellata*—Continued.

Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	320
Pounds per square inch	4,570
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	180
Pounds per square inch	2,570
Mean elongation at instant of rupture:	
Dry (per cent)	11
Wet (per cent)	11
Mean weight per unit length:	
Grams per meter	32.6
Pounds per foot	0.0219
Average breaking length:	
Meters	3,810
Feet	12,500
Moisture (per cent)	8.91

GREWIA ERIOCARPA Juss. Balitnong.

Local names: *Balibágo* (Batangas); *baria-an* (Union); *bariw-an* (Abra, Ilocano, Itneg, Nueva Ecija, and Pangasinan); *lanit, lapní, lapnít, lapí* (Cagayan).

A shrub or small tree with ovate, densely pubescent leaves, usually oblique, beneath white or nearly so; capsules densely hairy; widely distributed in the Philippines at low altitudes.

Grewia eriocarpa bast seems to be immune from the attack of the ordinary gray, green, and black molds that grow profusely on most of the other basts. The bast is wood brown; the strips vary from 2 to 5 millimeters in width and from 0.25 to 0.69 millimeter in thickness; they average 1,004 millimeters in length. Each strand of the rope averages nine strips thick. When dry the rope made of *Grewia eriocarpa* bast gives a medium tensile strength and breaking length. Wetting weakens the fiber about 3 per cent. The maximum variation from the mean tensile strength of the values obtained from the five wet specimens was 34 per cent, which indicates very poor agreement; whereas the corresponding value for the five dry test pieces was 19 per cent. Three of the five wet, and two of the five dry, test specimens failed in eye-splices. The minimum value in both series was given by test pieces rupturing in splices. Owing to its scarcity, the use of *Grewia eriocarpa* bast for the manufacture of cordage is infrequent.

A summary of the tests of this species made in the Bureau of Science is given in Table XXVI.

TABLE XXVI.—*Physical tests of rope made from the bast of Grewia eriocarpa.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	6.4
Inches	0.25
Mean perimeter, or girth:	
Millimeters	20
Inches	0.79
True mean sectional area:	
Square millimeters	25.9
Square inches	0.040
Ultimate tensile strength (dry):	
Mean in kilograms	102
Maximum in kilograms	121
Minimum in kilograms	83
Mean in pounds	225
Maximum in pounds	266
Minimum in pounds	183
Ultimate tensile strength (wet):	
Mean in kilograms	98.8
Maximum in kilograms	118
Minimum in kilograms	64.8
Mean in pounds	218
Maximum in pounds	261
Minimum in pounds	143
Mean ultimate tensile stregnth per unit area (dry):	
Kilograms per square centimeter	394
Pounds per square inch	5,630
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	381
Pounds per square inch	5,450
Mean elongation at instant of rupture:	
Dry (per cent)	6
Wet (per cent)	9
Mean weight per unit length:	
Grams per meter	20.2
Pounds per foot	0.0136
Average breaking length:	
Meters	5,050
Feet	16,600
Moisture (per cent)	8.31

GREWIA MULTIFLORA Juss. Danglin.

Local names: *Al-alinau* (Union); *alinau* (Amburayan, Ilocos Sur, Pangasinan, Sorsogon, Union, and Zambales); *aniláu* (Abra, Benguet, Ilocos Norte, Ilocos Sur, Union, and Pangasinan); *aplít* (Pampanga); *bagokon* (Guimaras, Mindoro); *benglaling* (Abra); *bulubukhón* (Guimaras); *dallag* (Gaddanes in Nueva Vizcaya); *danglí, kalitkalít* (Tayabas); *dangling*

(Bataan, Rizal, Tagalog); *danglog* (Cagayan); *durarong* (Ilocos Sur); *kanaroset* (Palawan); *lañgosig* (Bohol); *lanut* (Negrito in Pampanga); *lapnis, nagling* (Batangas, Cavite, Pampanga); *siapo* (Mindoro); *taroi* (Albay, Camarines); *umbubuyukan, imbubuykon* (Palawan).

A shrub or small tree, nearly glabrous; leaves oblong to oblong-ovate, up to 14 centimeters in length, often somewhat inequilateral, 3-nerved from the base; flowers in axillary umbels; fruit small, somewhat fleshy, obovoid, about 6 centimeters long, glabrous; common and widely distributed in the Philippines at low altitudes.

This bast is very common in the Ilocano provinces and is said to make a very durable rope for dry-weather use. *Grewia multiflora* is a pale yellow-orange, nonstaining fiber. The strips are soft; they average 6 millimeters wide, 0.46 millimeter thick, and 2,104 millimeters long. Each strand averages seven strips thick. *Grewia multiflora* makes a rope of more than average pliability, but of low tensile strength and breaking length. Immersion in water for twenty-four hours reduces the mean tensile strength 12 per cent. The five wet specimens gave more discordant strength values than the five dry ones, the greatest variation in the latter being 13, and in the former 29 per cent, from the mean. Three test pieces in each series failed in eye-splices, the maximum value in both series being given by specimens breaking in an eye-splice. The minimum value of the five dry specimens was obtained from a test piece that ruptured in the unspliced portion of the rope, whereas the minimum value of the five wet test pieces was given by a specimen that failed in an eye-splice.

A summary of the tests of this species made in the Bureau of Science is given in Table XXVII.

TABLE XXVII.—*Physical tests of rope made from the bast of Grewia multiflora.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	11.5
Inches	0.45
Mean perimeter, or girth:	
Millimeters	36
Inches	1.42
True mean sectional area:	
Square millimeters	85.4
Square inches	0.132

TABLE XXVII.—*Physical tests of rope made from the bast of Grewia multiflora*—Continued.

Ultimate tensile strength (dry):	
Mean in kilograms	321
Maximum in kilograms	363
Minimum in kilograms	299
Mean in pounds	708
Maximum in pounds	800
Minimum in pounds	660
Ultimate tensile strength (wet):	
Mean in kilograms	283
Maximum in kilograms	315
Minimum in kilograms	202
Mean in pounds	624
Maximum in pounds	695
Minimum in pounds	445
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	376
Pounds per square inch	5,360
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	332
Pounds per square inch	4,730
Mean elongation at instant of rupture:	
Dry (per cent)	10
Wet (per cent)	11
Mean weight per unit length:	
Grams per meter	87.9
Pounds per foot	0.0591
Average breaking length:	
Meters	3,660
Feet	12,000
Moisture (per cent)	13.12

MORACEAE

ALLAEANTHUS GLABER Warb. Malambiñgan.

Local names: *Alibabai* (Cagayan, Itneg); *alibakai* (Cagayan); *alitagtág* or *balitagtág* (Camarines); *alokon, baeg, boñgon* (Pangasinan); *babayan, imkabau* (Nueva Ecija); *buñgon* (Abra, Benguet, Ilocos Norte, Ilocos Sur); *kabag* (Mindoro); *karud* (Misamis); *liba* (Davao); *malakadiós* (Masbate); *malambíñgan* (Basilan).

A medium-sized tree with oblong, nearly glabrous leaves; the male flowers in long slender amentlike inflorescences; fruits fleshy, globose; of local distribution at low altitudes in northern Luzon.

The crude bast strips used in making this rope show great variation in color, structure, and size. Some of the strips are light yellow, soft, and thin. Others have a decided brownish tinge and are coarse and hard. The strands average five strips thick, and the strips vary from 2 to 12 millimeters in width and from 0.36 to 1.2 millimeters in thickness. This bast is characterized by a fine fuzz. Plate IV, fig. 7, shows its peculiar nature. Numerous ragged spots and irregularities occur in the rope that give it a rough appearance.

When dry, rope made of this bast is very low in tensile strength and breaking length, perhaps in part due to the ragged spots. Wetting increases the mean tensile strength about 10 per cent. Filipinos state that rope made from this bast is more durable during the rainy season than the average fibers used. The maximum variation from the mean tensile strength of the five dry test specimens was 15 per cent, whereas that from the mean of the five wet test pieces was 19 per cent. Four of the dry, and two of the wet, test pieces ruptured in eye-splices. Of particular interest is the extraordinary mean elongation of the wet specimens, 25 per cent, which is nearly double that given by the dry test pieces.

A summary of the tests of this species made in the Bureau of Science is given in Table XXVIII.

TABLE XXVIII.—*Physical tests of rope made from the bast of Allaeanthus glaber.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	12.4
Inches	0.49
Mean perimeter, or girth:	
Millimeters	39
Inches	1.54
True mean sectional area:	
Square millimeters	100.2
Square inches	0.155
Ultimate tensile strength (dry):	
Mean in kilograms	231
Maximum in kilograms	265
Minimum in kilograms	204
Mean in pounds	509
Maximum in pounds	585
Minimum in pounds	450
Ultimate tensile strength (wet):	
Mean in kilograms	253
Maximum in kilograms	302
Minimum in kilograms	209
Mean in pounds	557
Maximum in pounds	665
Minimum in pounds	460

TABLE XXVIII.—*Physical tests of rope made from the bast of Allaeanthus glaber*—Continued.

Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	231
Pounds per square inch	3,290
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	253
Pounds per square inch	3,590
Mean elongation at instant of rupture:	
Dry (per cent)	13
Wet (per cent)	25
Mean weight per unit length:	
Grams per meter	94.4
Pounds per foot	0.0635
Average breaking length:	
Meters	2,440
Feet	8,030
Moisture (per cent)	13.86

ARTOCARPUS COMMUNIS Forst. Antipolo.

Local names: *Antipólo* (Bataan, Cagayan, Laguna, Manila, Mindoro, Palawan, Rizal, Union, Zambales); *antiponong lalaki* (Rizal); *kamansí* (Leyte); *pákak* (Cagayan, Ilocos Sur, Union, Zambales); *pasak* (Abra, Ilocos Sur, Union); *tipólo* (Camarines, Negros).

A tree with abundant milky juice; very large, pinnately lobed leaves; and large, globose, fleshy, many-seeded, rough fruits; the male flowers minute, very numerous, in large, dense, oblong-ovate, solid inflorescences; common and widely distributed in the Philippines, cultivated and wild.

This bast is a striking example of the different properties that a fiber may assume, depending upon the age of the plant from which it is taken, in contrast to variation in its appearance and properties due to the manner of its manipulation and preparation, as described under *Abroma fastuosa.*

Plate IV, fig. 9, shows a sample of rope made from bast from the trunk of an old tree obtained in April, 1916, at Sappaac, Abra Province. Plate I, fig. 1, illustrates this particular piece of rope in the process of manufacture. The strips of bast are chestnut in color, are about 1.5 meters long, and are exceedingly hard and stiff.

Owing to the excessive labor required in the preparation of the mature bast it is seldom used for making rope, though for some purposes it excels all other fibers in durability. After the old bast has been stripped, it must be beaten a long time in order to give it a small degree of pliability. The bast is first cut, or rather torn, into three ribbons, which are then tightly twisted, separately, to form the strands of a rope. These strands are then fastened in the crude wooden rope-laying apparatus shown in Plate I, fig. 1, and laid into rope. This sample of rope was just long enough to make one tensile-strength test, the results of which are recorded in Table XXIX.

The rope possesses little flexibility, and a piece 20 centimeters long held horizontally was not deformed by flexion; ordinary ropes of this size under similar conditions would show appreciable deflection. Plate VIII, fig. 4, shows that each strand is made of only one very rough strip of bast; it averages 1.68 millimeters thick and 18 millimeters wide.

In sharp contrast to this sample of hard dark bast is that illustrated in Plate IV, fig. 8, which was obtained from a young tree in Dolores, Abra Province, in 1917. It is of a salmon-buff color, is soft, and makes a rope that is pliable and far more uniform than that made of the chestnut-colored bast. The strands are from four to eleven bast strips thick; the latter vary in width from 1 to 4 millimeters, in thickness from 0.13 to 0.66 millimeter, and have a mean length of 610 millimeters. It will be noticed that the bast strips are comparatively short. When dry the rope made of the two basts is low in tensile strength and breaking length, although that from the old lignified bast is slightly stronger than that made of the young bast. The maximum variations from the mean tensile strength of the dry and the wet specimens of the young bast were 20 and 16 per cent, respectively. Three specimens in each series of five ruptured in an eye-splice. Wetting has little influence on the tenacity of the bast and causes a decrease in the mean tensile strength of only 2 per cent.

Filipinos emphasize the durability of rope made of *Artocarpus communis*, particularly that made of the old bast. It is said to withstand prolonged wetting and to give good service even when wetted and dried alternately. The rope is principally used in the form of traces, to yoke carabaos for field work. This service is severe; for, in addition to being alternately wet and dry, the rope is subjected to abrasion by being dragged in the gritty earth. The Ilocanos of Sappaac believe that old bast is more durable than rawhide.

A summary of the tests of this species made in the Bureau of Science is given in Table XXIX.

TABLE XXIX.—*Physical tests of rope made from the bast of Artocarpus communis.*

	From young bast.[a]	From old bast.[b]
Mean diameter:		
Millimeters	6.1	9.6
Inches	0.24	0.38
Mean perimeter, or girth:		
Millimeters	19	30
Inches	0.75	1.18
True mean sectional area:		
Square millimeters	28.4	60.8
Square inches	0.044	0.094
Ultimate tensile strength (dry):		
Mean in kilograms	101	[c] 222
Maximum in kilograms	121	
Minimum in kilograms	81.1	
Mean in pounds	223	490
Maximum in pounds	267	
Minimum in pounds	179	
Ultimate tensile strength (wet):		
Mean in kilograms	96.5	(d)
Maximum in kilograms	112	(d)
Minimum in kilograms	84.3	(d)
Mean in pounds	213	(d)
Maximum in pounds	246	(d)
Minimum in pounds	186	(d)
Mean ultimate tensile strength per unit area (dry):		
Kilograms per square centimeter	356	367
Pounds per square inch	5,070	5,220
Mean ultimate tensile strength per unit area (wet):		
Kilograms per square centimeter	340	(d)
Pounds per square inch	4,830	(d)
Mean elongation at instant of rupture:		
Dry per cent	11	(d)
Wet do	15	(d)
Mean weight per unit length:		
Grams per meter	22.8	48.8
Pounds per foot	0.0153	0.0328
Average breaking length:		
Meters	4,450	4,560
Feet	14,600	14,900
Moisture per cent	9.25	14.7

[a] Rope made at Abbualan, Dolores, Abra Province.

[b] Rope made at Sappaac, Abra Province, based on assumed true area.

[c] Only sufficient rope to make one test.

[d] No test made.

FICUS BENJAMINA Linn. Balete.[34]

Local names: *Auñgu* (Isabela); *baléte* (Ilocano); *baletéon, salisi* (Nueva Vizcaya); *balete-pulá* (Laguna, Tayabas); *baléti* (Abra, Bataan, Camarines, Cavite, Ilocos Norte, Laguna, Manila, Nueva Ecija, Pangasinan, Pampanga); *balíti* (Pampanga); *baliting-ibon* (Batangas, Rizal); *gisi* (Ibanak, Apayao Subprovince); *kolis* (Bataan); *kuliamat* (Negrito in Bataan); *sirisin* (Cagayan).

A strangling fig with coriaceous, glabrous, densely nerved, smooth, entire leaves and small, axillary, globose fruits; throughout the Philippines at low altitudes.

Ficus benjamina bast strips are salmon-buff and show considerable variation; some are soft and pliable, others are hard and stiff. They vary in width from 2 to 5 millimeters, their average thickness is 0.60 millimeter, and their mean length is 1,227 millimeters. The strands are about ten strips thick. When dry, rope made from this bast has a medium tensile strength and breaking length. Wetting the fiber reduces the tenacity by 2 per cent, which for practical purposes is negligible. All of the five wet test specimens ruptured in the unspliced portion of the rope, whereas two of the five dry ones failed in eye-splices. The maximum variations from the mean tensile strength in the dry and the wet series were 19 and 22 per cent, respectively. Immersion in water gives rise to a markedly higher mean elongation. In the Philippines bast from *Ficus benjamina* is not commonly used for rope making owing to its comparative scarcity.

A summary of the tests of this species made in the Bureau of Science is given in Table XXX.

TABLE XXX.—*Physical tests of rope made from the bast of Ficus benjamina.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	7.3
Inches	0.29
Mean perimeter, or girth:	
Millimeters	23
Inches	0.91
True mean sectional area:	
Square millimeters	32.5
Square inches	0.050

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[34] "Balete" or "baliti," in the majority of Philippine dialects, is a broadly generic term used to designate all the "strangling" figs (*Ficus* spp.), and is rarely or never applied to any epiphytic or climbing plant of any other family.

TABLE XXX.—*Physical tests of rope made from the bast of Ficus benjamina*—Continued.

Ultimate tensile strength (dry):	
Mean in kilograms	156
Maximum in kilograms	176
Minimum in kilograms	126
Mean in pounds	343
Maximum in pounds	388
Minimum in pounds	277
Ultimate tensile strength (wet):	
Mean in kilograms	153
Maximum in kilograms	164
Minimum in kilograms	119
Mean in pounds	338
Maximum in pounds	362
Minimum in pounds	262
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	480
Pounds per square inch	6,830
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	471
Pounds per square inch	6,700
Mean elongation at instant of rupture:	
Dry (per cent)	9
Wet (per cent)	15
Mean weight per unit length:	
Grams per meter	31.0
Pounds per foot	0.0208
Average breaking length:	
Meters	5,030
Feet	16,500
Moisture (per cent)	8.41

FICUS FORSTENII Miq. Balete.

Local names: *Baléte, balíte* (Bataan, Mindoro, Rizal, Zambales); *basakla* (Abra, Ilocano); *dalákit* (Negros); *lañgaban* (Moro in Cotabato); *puos* or *puspus* (Ilocano, Itneg).

A strangling fig with oblong, distantly nerved, coriaceous leaves and ellipsoid, sessile, axillary fruits; throughout the Philippines at low altitudes.

Ficus forstenii bast is ochraceous salmon, and numerous fine fibrils protruding from the strips give the rope a ragged appearance. Plate IV, fig. 11, shows this hairy character and would seem to indicate that the fiber has been beaten to make it more pliable. The average length of the bast strips in the rope obtained for test is 738 millimeters. The strands are four strips thick. When dry, rope made of *Ficus forstenii* is very low in tensile strength and breaking length. However, immersion for twenty-four hours in water improves the tenacity

44 per cent. All of the wet specimens failed in the unspliced portion of the rope, and the maximum variation from the mean tensile strength in the five specimens tested was 21 per cent. Two of the dry specimens ruptured in splices, the greatest variation from the mean being 23 per cent. Wetting appreciably increases the mean ultimate elongation of the rope.

A summary of the tests of this species made in the Bureau of Science is given in Table XXXI.

TABLE XXXI.—*Physical tests of rope made from the bast of Ficus forstenii.*

[Rope made at Dolores, Abra Province.]

Mean diameter:	
Millimeters	7.0
Inches	0.28
Mean perimeter, or girth:	
Millimeters	22
Inches	0.87
True mean sectional area:	
Square millimeters	38.8
Square inches	0.060
Ultimate tensile strength (dry):	
Mean in kilograms	59.8
Maximum in kilograms	70.3
Minimum in kilograms	46.3
Mean in pounds	132
Maximum in pounds	155
Minimum in pounds	102
Ultimate tensile strength (wet):	
Mean in kilograms	86.2
Maximum in kilograms	104
Minimum in kilograms	71.2
Mean in pounds	190
Maximum in pounds	230
Minimum in pounds	157
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	154
Pounds per square inch	2,200
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	222
Pounds per square inch	3,160
Mean elongation at instant of rupture:	
Dry (per cent)	11
Wet (per cent)	18
Mean weight per unit length:	
Grams per meter	37.3
Pounds per foot	0.0251
Average breaking length:	
Meters	1,600
Feet	5,260
Moisture (per cent)	9.71

FICUS PACHYPHYLLA Merr. Balete.

Local names: *Baliti* (Laguna); *lunug* (Occidental Negros); *pasakla* (Abra, Itneg).

A strangling fig with very coriaceous, glabrous, somewhat elliptic, rather densely nerved leaves and nearly globose axillary fruits; of local distribution at low altitudes and widely distributed in the Philippines.

Like *Ficus forstenii* bast, that from *Ficus pachyphylla* also is characterized by finely frayed filaments that cover the surface. The strips of bast are uniformly pecan brown; they average 2 millimeters wide, 0.28 millimeter thick, and 838 millimeters long. Each strand averages eight strips thick.

Rope made of *Ficus pachyphylla* has good strength, particularly when wetted. When dry it has a medium tensile strength and breaking length, but after immersion in water for twenty-four hours its tensile strength is increased 17 per cent. However, the results are discordant, the maximum variation from the mean of the five specimens being 25 per cent. The dry tensile-strength values showed better agreement, the maximum variation from the mean being 16 per cent. Four of the five dry, and three of the five wet, test specimens ruptured in eye-splices. Filipinos say that rope made of this bast is very durable.

A summary of the tests of this species made in the Bureau of Science is given in Table XXXII.

TABLE XXXII.—*Physical tests of rope made from the bast of Ficus pachyphylla.*

[Rope made at Dolores, Abra Province.]

Mean diameter:	
Millimeters	7.0
Inches	0.28
Mean perimeter, or girth:	
Millimeters	22
Inches	0.87
True mean sectional area:	
Square millimeters	32.3
Square inches	0.050
Ultimate tensile strength (dry):	
Mean in kilograms	150
Maximum in kilograms	161
Minimum in kilograms	126
Mean in pounds	330
Maximum in pounds	355
Minimum in pounds	277

TABLE XXXII.—*Physical tests of rope made from the bast of Ficus pachyphylla*—Continued.

Ultimate tensile strength (wet):	
Mean in kilograms	176
Maximum in kilograms	209
Minimum in kilograms	132
Mean in pounds	388
Maximum in pounds	460
Minimum in pounds	290
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	464
Pounds per square inch	6,600
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	544
Pounds per square inch	7,760
Mean elongation at instant of rupture:	
Dry (per cent)	12
Wet (per cent)	17
Mean weight per unit length:	
Grams per meter	30.3
Pounds per foot	0.0204
Average breaking length:	
Meters	4,930
Feet	16,200
Moisture (per cent)	9.09

FICUS PALAWANENSIS Merr. Balete.

Local names: *Agamid, agamit* (Abra, Itneg); *baléte* (Cavite, Laguna, Lanao, Palawan, Tayabas); *tibíg* (Misamis).

A large strangling fig with coriaceous, oblong, glabrous, acuminate leaves and axillary ellipsoid fruits; found throughout the Philippines at low altitudes.

Like the other *Ficus* basts tested, the strips of *Ficus palawanensis* also are characterized by numerous fibrils that cover the surface. The bast strips are colored bittersweet pink; they average 0.41 millimeter thick, 3 millimeters wide, and 821 millimeters long. The strands average eight strips thick.

Of all the *Ficus* basts tested, *Ficus palawanensis* is the strongest, and it is one of the highest in tensile strength and breaking length. An examination of Table XLII will show that it is stronger than machine-laid rope made of maguey Government grade Cebu No. 2, and is nearly twice as strong as hand-laid maguey rope made of unclassified fiber extracted by the salt-water retting process in Ilocos Sur. In fact, *Ficus palawanensis* bast rope compares very favorably in strength with machine-made "G" grade abacá rope, and in one case exceeds the mean tensile strength of abacá rope 26 millimeters in circumference made of "G" grade fiber. When wetted for twenty-four hours, rope made of *Ficus palawanensis* bast is increased, and maguey is decreased, in tensile strength, and the former is 18 per cent more tenacious than the latter.

Four dry, and four wet, specimens ruptured in the unspliced portion of the rope, but the results obtained from the dry series of tests were much more uniform than those from the wet test pieces. The latter behaved erratically, and the maximum variation from the mean was 30 per cent, while the greatest variation from the average value in the dry series was 12 per cent. The mean elongation of the wetted specimens was considerably higher than that given by the dry test pieces.

Filipinos say that rope made of *Ficus palawanensis* bast is both stronger and more durable than that made of maguey. On account of its great strength, toughness, and durability the fiber is used for making wild-hog traps.

A summary of the tests of this species made in the Bureau of Science is given in Table XXXIII.

TABLE XXXIII.—*Physical tests of rope made from the bast of Ficus palawanensis.*

[Rope made at Dolores, Abra Province.]

Mean diameter:	
Millimeters	6.1
Inches	0.24
Mean perimeter, or girth:	
Millimeters	19
Inches	0.75
True mean sectional area:	
Square millimeters	20.5
Square inches	0.032
Ultimate tensile strength (dry):	
Mean in kilograms	154
Maximum in kilograms	167
Minimum in kilograms	136
Mean in pounds	339
Maximum in pounds	368
Minimum in pounds	300
Ultimate tensile strength (wet):	
Mean in kilograms	157
Maximum in kilograms	195
Minimum in kilograms	110
Mean in pounds	346
Maximum in pounds	429
Minimum in pounds	243

TABLE XXXIII.—*Physical tests of rope made from the bast of Ficus palawanensis*—Continued.

Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	752
Pounds per square inch	10,700
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	766
Pounds per square inch	10,900
Mean elongation at instant of rupture:	
Dry (per cent)	12
Wet (per cent)	19
Mean weight per unit length:	
Grams per meter	24.7
Pounds per foot	0.0166
Average breaking length:	
Meters	6,230
Feet	20,400
Moisture (per cent)	9.08

BORAGINACEAE

CORDIA CUMINGIANA Vid. Anonang-lalaki.

Local names: *Anónang-laláki* (Mindoro); *maratarong* (Ilocano, Benguet).

A small tree with broadly ovate, cordate, somewhat hairy leaves, many-flowered inflorescences, and small, ovoid, fleshy fruits; of local occurrence at low altitudes in Luzon.

The strips of this bast that constitute the strands of the rope procured for testing vary considerably in size and color; some strips are 15 millimeters wide and 1 millimeter thick, and are stiff and amber brown. Others are only 0.2 millimeter thick, 6 millimeters wide, soft, and buff. Plate V, fig. 1, shows that most of the *Cordia cumingiana* bast strips are broad and very coarse. The strands average seven strips thick.

When dry, rope made of this bast is low in tensile strength and breaking length. Wetting decreases the mean tensile strength of the fiber 6 per cent, but for all practical purposes does not affect the mean elongation. All of the wet specimens broke in the unspliced portion of the rope, whereas three of the five dry specimens ruptured in eye-splices. The latter tests showed more discordant results than the former, the maximum variations from the mean in the five dry, and the five wet, specimens being 20 per cent and 13 per cent, respectively.

A summary of the tests of this species made in the Bureau of Science is given in Table XXXIV.

TABLE XXXIV.—*Physical tests of rope made from the bast of Cordia cumingiana.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	12.1
Inches	0.48
Mean perimeter, or girth:	
Millimeters	38
Inches	1.50
True mean sectional area:	
Square millimeters	86.8
Square inches	0.135
Ultimate tensile strength (dry):	
Mean in kilograms	337
Maximum in kilograms	383
Minimum in kilograms	270
Mean in pounds	743
Maximum in pounds	845
Minimum in pounds	595
Ultimate tensile strength (wet):	
Mean in kilograms	316
Maximum in kilograms	356
Minimum in kilograms	275
Mean in pounds	696
Maximum in pounds	785
Minimum in pounds	605
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	388
Pounds per square inch	5,500
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	364
Pounds per square inch	5,160
Mean elongation at instant of rupture:	
Dry (per cent)	16
Wet (per cent)	16
Mean weight per unit length:	
Grams per meter	75.6
Pounds per foot	0.0508
Average breaking length:	
Meters	4,450
Feet	14,600
Moisture (per cent)	12.61

CORDIA MYXA Linn. Anonang.

Local names: *Anónang* (Albay, Bataan, Batangas, Benguet, Camarines, Ilocos Sur, Laguna, Mindoro, Pampanga, Pangasinan, Rizal, Sorsogon, Tayabas); *bibíli* (Visayan); *gúma* (Balabac); *salóyong* (Tagalog); *sinalígan* (Ilocos Sur).

A tree, usually about 10 meters high, glabrous or nearly so; leaves ovate to elliptic-ovate, margins usually repand; inflorescences lax, axillary and terminal, 5 to 10 centimeters long; flowers white or yellowish-white, small; drupe fleshy, ovoid, about 1 centimeter long, yellowish white, the pulp scanty; common and widely distributed in the Philippines at low altitudes.

Cordia myxa bast is wood brown, and the strands of the rope used in the test are from eleven to fifteen strips thick. The strips average 3 millimeters wide and 0.10 millimeter thick. When dry, rope made of *Cordia myxa* bast is very low in tensile strength and breaking length. Wetting decreases the mean tensile strength 19 per cent. Filipinos say that the fiber is not suited for use in the wetted condition. Four of the five wet, and three of the five dry, specimens failed outside of eye-splices. The latter series of tests showed better agreement than the former, the maximum variation from the mean tensile strength being 15 and 34 per cent, respectively.

A summary of the tests of this species made in the Bureau of Science is given in Table XXXV.

TABLE XXXV.—*Physical tests of rope made from the bast of* Cordia *myxa.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	7.96
Inches	0.31
Mean perimeter, or girth:	
Millimeters	25
Inches	0.99
True mean sectional area:	
Square millimeters	44.5
Square inches	0.069
Ultimate tensile strength (dry):	
Mean in kilograms	144
Maximum in kilograms	162
Minimum in kilograms	122
Mean in pounds	318
Maximum in pounds	357
Minimum in pounds	269
Ultimate tensile strength (wet):	
Mean in kilograms	117
Maximum in kilograms	157
Minimum in kilograms	101
Mean in pounds	257
Maximum in pounds	345
Minimum in pounds	222

TABLE XXXV.—*Physical tests of rope made from the bast of Cordia myxa*—Continued.

Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	324
Pounds per square inch	4,610
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	263
Pounds per square inch	3,730
Mean elongation at instant of rupture:	
Dry (per cent)	11
Wet (per cent)	14
Mean weight per unit length:	
Grams per meter	34.9
Pounds per foot	0.0235
Average breaking length:	
Meters	4,125
Feet	13,500
Moisture (per cent)	8.54

GNETACEAE

GNETUM sp. Kuliat.

Local names: *Kaliát* (Ilocano); *kaliát* or *kandiát* (Benguet); *kandiát* (Itneg); *kuliát* (Bataan).

A small tree with oblong, glossy, entire, acuminate, thin leaves; flowers minute, crowded in the points of the inflorescences; fruit ellipsoid, one-seeded, about 2 centimeters long, the seed edible; widely distributed in the Philippines at low altitudes; usually sylvan.

Gnetum sp. bast strips are rich brown, free from irregularities, and have a decidedly waxy touch and appearance. The waxy surface imparts a glossy sheen and, combined with the smoothness of the strips, assists them to slip over each other when strained. The strands of rope average ten strips thick. The strips vary in width from 1 to 3 millimeters, average 0.25 millimeter thick, and have a mean length of 503 millimeters. It will be noted that the strips are not only narrow and thin, but that they are shorter than those of any other bast measured.

Of all the bast ropes tested, that made of *Gnetum* sp. fiber is the most tenacious and has the highest breaking length; moreover, it is exceptionally pliable. *Gnetum* sp. rope is stronger than machine-laid maguey rope made of Government grade Cebu No. 2 fiber and in tenacity approaches closely cordage made of the most superior grade of abacá fiber. When wetted for twenty-four hours this bast rope increases 31 per cent in strength and is actually stronger than machine-laid abacá rope made of "F" grade fiber.

All test specimens of both the five dry, and the five wet, specimens, excepting one in the latter, ruptured outside of eye-splices. The maximum variation from the mean tensile strength of the dry specimen values was 29 per cent, and that of the wet specimens was only 11 per cent. Wetting not only greatly increases, but improves, their uniformity.

Rope made of *Gnetum* sp. bast is held in high esteem by Filipinos because of its great strength, pliability, and lightness, and is considered by Igorots and Ilocanos in Benguet, Abra, and Union superior to that made of any other local fiber. It is preferred for making wild-hog traps and for mounting seines and for trawl fishing. Fiber for these purposes is subjected to severe exposure and treatment and must be durable and reliable. When used for mounting nets and for fishing lines the bast meets with extraordinarily hard usage. It is customary to stretch a rope from one bank of a river to the other, and at regular intervals to suspend short lines to which hooks are attached. The rope of course is submerged, and frequently considerable débris becomes lodged against it. More than one instance is on record in which a man was saved from being washed away by grasping such a rope, of about the size of a lead pencil.

A summary of the tests of this species made in the Bureau of Science is given in Table XXXVI.

TABLE XXXVI.—*Physical tests of rope made from the bast of Gnetum sp.*

[Rope made at Disdis, Benguet Subprovince.]

Mean diameter:	
Millimeters	5.7
Inches	0.23
Mean perimeter, or girth:	
Millimeters	18
Inches	0.71
True mean sectional area:	
Square millimeters	21.5
Square inches	0.033
Ultimate tensile strength (dry):	
Mean in kilograms	166
Maximum in kilograms	214
Minimum in kilograms	142
Mean in pounds	366
Maximum in pounds	471
Minimum in pounds	312

TABLE XXXVI.—*Physical tests of rope made from the bast of Gnetum sp*—Continued.

Ultimate tensile strength (wet):	
Mean in kilograms	217
Maximum in kilograms	240
Minimum in kilograms	205
Mean in pounds	478
Maximum in pounds	529
Minimum in pounds	452
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	773
Pounds per square inch	11,100
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	1,000
Pounds per square inch	14,500
Mean elongation at instant of rupture:	
Dry (per cent)	10
Wet (per cent)	12
Mean weight per unit length:	
Grams per meter	19.7
Pounds per foot	0.0132
Average breaking length:	
Meters	8,450
Feet	27,700
Moisture (per cent)	11.45

BOMBACACEAE

BOMBAX CEIBA Linn. Malabulak.

Local names: *Bóboi* (Tagalog); *bobor* or *taroktók* (Abra, Ilocano); *bubui-gubat* (Mindoro, Rizal); *dóldol* (Ilocano); *kápas*, *kapói* (Jolo); *malabúlak* (Laguna, Nueva Ecija).

A very large deciduous tree, the trunk with large pyramidal spines; leaves palmately compound, leaflets oblong to lanceolate, 10 to 20 centimeters long; flowers very large, red, appearing before the leaves; capsules about 15 centimeters long; seeds hairy; throughout the Philippines at low altitudes.

Bombax ceiba bast is orange-buff. The strips of rope procured for the test average 6 millimeters wide, 0.38 millimeter thick, and 967 millimeters long. Each strand averages ten strips thick.

When dry, rope made of this fiber is medium in tensile strength and breaking length. Wetting diminishes its mean tensile strength 13 per cent. Three of the four dry, and one of the five wet, specimens broke in eye-splices. The maximum variation from the mean tensile strength of the dry test pieces was 9 per cent, and that shown by the wet series was 37 per cent.

This bast is rare and, therefore, is not commonly used for rope making. Filipinos say that it is suitable for wet-weather use.

A summary of the tests of this species made in the Bureau of Science is given in Table XXXVII.

TABLE XXXVII.—*Physical tests of rope made from the bast of Bombax ceiba.*

[Rope made at Langiden, Abra Province.]

Mean diameter:	
Millimeters	8.3
Inches	0.33
Mean perimeter, or girth:	
Millimeters	26
Inches	1.02
True mean sectional area:	
Square millimeters	43.0
Square inches	0.067
Ultimate tensile strength (dry):	
Mean in kilograms	174
Maximum in kilograms	184
Minimum in kilograms	158
Mean in pounds	383
Maximum in pounds	405
Minimum in pounds	348
Ultimate tensile strength (wet):	
Mean in kilograms	151
Maximum in kilograms	176
Minimum in kilograms	94.8
Mean in pounds	332
Maximum in pounds	387
Minimum in pounds	209
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	405
Pounds per square inch	5,720
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	351
Pounds per square inch	4,960
Mean elongation at instant of rupture:	
Dry (per cent)	8
Wet (per cent)	10
Mean weight per unit length:	
Grams per meter	37.7
Pounds per foot	0.0253
Average breaking length:	
Meters	4,620
Feet	15,150
Moisture (per cent)	15.78

ULMACEAE

TREMA ORIENTALIS Blume. Anabiong.

Local names: *Agandung* (Cagayan); *alindagon* (Balabac, Moro); *anabion* (Visayan and Tagalog); *anabiong* (Mindoro, Negros, Rizal); *anagum* (Bicol); *anariong* (Batanes); *anarong* (Zambales); *andaluyong* (Bukidnon); *annadung, hubulos* (Bontoc); *dalunot maladurung* (Bataan); *hagod* (Laguna, Tayabas); *hanag-dúng, balibágo* (Rizal); *hanadióng, hinagdúng, inangdón, kungdón* (Mindoro); *hanagdóng* (Guimaras, Samar, Surigao, Tayabas); *hinagdúng* (Visayan); *inangdón* (Mindoro); *indai-luging* (Lanao); *lagod, balibágo, dalunot, hanadióng* (Tagalog); *lamai, arandóng* (Abra); *malarurung* (Igorot, Tagalog); *malasikongdúron, dalunit, hinlalaong* (Pampanga); *nagdón* (Occidental Negros); *pañgarandóngen* (Pangasinan); *pañgarandúñgin* (Benguet); *tatagtág* (Guimaras).

A small tree with oblong, ovate, somewhat harsh, oblique, acuminate leaves; small axillary inflorescences of very numerous minute flowers; and small, fleshy, ovoid drupes; very common and widely distributed in settled areas of the Philippines.

Trema orientalis bast strips are cinnamon in color. They average 3 millimeters wide and 0.38 millimeter thick. The strands average nine strips thick. Plate V, fig. 5, shows that the strips are very irregular and ragged looking.

When dry, rope made of *Trema orientalis* has the lowest tensile strength and breaking length of all ropes tested. However, when wetted, its resistance is nearly doubled. Even so, the tensile strength is low. Filipinos say that this bast is very weak, and that it makes a poor rope. For this reason it is not commonly used for the fabrication of cordage.

A summary of the tests of this species made in the Bureau of Science is given in Table XXXVIII.

TABLE XXXVIII.—*Physical tests of rope made from the bast of Trema orientalis.*

[Rope made at Dolores, Abra Province.]

Mean diameter:	
Millimeters	8.3
Inches	0.33
Mean perimeter, or girth:	
Millimeters	26
Inches	1.02
True mean sectional area:	
Square millimeters	46.6
Square inches	0.072

TABLE XXXVIII.—*Physical tests of rope made from the bast of Trema orientalis*—Continued.

Ultimate tensile strength (dry):	
Mean in kilograms	62.6
Maximum in kilograms	79
Minimum in kilograms	46.7
Mean in pounds	138
Maximum in pounds	174
Minimum in pounds	103
Ultimate tensile strength (wet):	
Mean in kilograms	122
Maximum in kilograms	122
Minimum in kilograms	121
Mean in pounds	268
Maximum in pounds	269
Minimum in pounds	267
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	134
Pounds per square inch	1,920
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	262
Pounds per square inch	3,720
Mean elongation at instant of rupture:	
Dry (per cent)	7
Wet (per cent)	21
Mean weight per unit length:	
Grams per meter	44.1
Pounds per foot	0.0296
Average breaking length:	
Meters	1,420
Feet	4,660
Moisture (per cent)	8.90

ANNONACEAE

GONIOTHALAMUS AMUYON Blanco. Amuyong.

Local names: *Amúyong* (Tayabas); *lanútan* (Occidental Negros); *sagiát* (Ilocano, Abra).

A glabrous tree with oblong coriaceous leaves, rather large flowers, and cylindric, elongated aromatic fruits; of local occurrence, but widely distributed at low altitudes in the Philippines.

The most conspicuous characteristic of *Goniothalamus amuyon* bast is its attractive apricot-buff color. Like most of the basts tested, the fiber of this rope is in the form of strips, which average 3 millimeters wide, 0.33 millimeter thick, and 794 millimeters long.

When dry, rope made of this bast is very low in tensile strength and breaking length. Wetting reduces the mean tensile strength 15 per cent. The wet specimens gave very uniform breaks, the maximum variation from the mean being 9 per cent, while that shown by the five dry specimens was 21 per cent. Three of the dry, and two of the wet, specimens failed in eye-splices.

A summary of the tests of this species made in the Bureau of Science is given in Table XXXIX.

TABLE XXXIX.—*Physical tests of rope made from the bast of Goniothalamus amuyon.*

[Rope made at Dolores, Abra Province.]

Mean diameter:	
Millimeters	9.2
Inches	0.36
Mean perimeter, or girth:	
Millimeters	29
Inches	1.14
True mean sectional area:	
Square millimeters	40.9
Square inches	0.063
Ultimate tensile strength (dry):	
Mean in kilograms	141
Maximum in kilograms	157
Minimum in kilograms	112
Mean in pounds	311
Maximum in pounds	347
Minimum in pounds	247
Ultimate tensile strength (wet):	
Mean in kilograms	120
Maximum in kilograms	130
Minimum in kilograms	109
Mean in pounds	264
Maximum in pounds	287
Minimum in pounds	241
Mean ultimate tensile strength per unit area (dry):	
Kilograms per square centimeter	345
Pounds per square inch	4,940
Mean ultimate tensile strength per unit area (wet):	
Kilograms per square centimeter	293
Pounds per square inch	4,180
Mean elongation at instant of rupture:	
Dry (per cent)	9
Wet (per cent)	13
Mean weight per unit length:	
Grams per meter	38.4
Pounds per foot	0.0258
Average breaking length:	
Meters	3,680
Feet	12,050
Moisture (per cent)	8.65

VARIATIONS IN TESTS

The handmade bast-fiber rope, with one or two exceptions, gave very erratic results. Taken as a whole the wet specimens gave somewhat more erratic results than the dry ones. For the dry specimens the maximum average variation from the mean was 17 per cent, and for the wet, 20 per cent. Table XL records the maximum variations from the mean in tensile-strength tests of five samples, each, of dry and wet rope specimens.

TABLE XL.—*Maximum variation from the mean tensile strength of rope in the dry and the wet series of five tests each.*

HANDMADE BAST-FIBER ROPES.

Fiber.	Maximum variation from mean tensile strength.	
	Dry series.	Wet series.
	Per cent.	*Per cent.*
Abroma fastuosa; unretted bast	21	22
Abroma fastuosa; retted bast	[a] 6	(b)
Commersonia bartramia	20	26
Helicteres hirsuta	17	11
Kleinhovia hospita	17	30
Pterocymbium tinctorium	26	18
Pterospermum diversifolium	14	8
Sterculia crassiramea	7	16
Sterculia foetida	4	[c] 28
Sterculia oblongata	9	17
Sterculia stipularis	29	22
Bombycidendron vidalianum	18	30
Malachra fasciata	20	6
Sida acuta	12	[c] 7
Thespesia lampas	24	21
Urena lobata	34	11
Columbia blancoi	16	10
Corchorus olitorius	7	18
Grewia eriocarpa	19	34
Grewia bilamellata	11	29
Grewia multiflora	13	29
Allaeanthus glaber	15	19
Artocarpus communis; young bast	20	16
Ficus benjamina	19	22
Ficus forstenii	23	21
Ficus pachyphylla	16	25
Ficus palawanensis	12	30
Cordia cumingiana	20	13
Cordia myxa	15	34
Gnetum sp	29	11
Bombax ceiba	[c] 9	37
Trema orientalis	25	(d)
Goniothalamus amuyon	21	9
Average	17	20

TABLE XL.—*Maximum variation from the mean tensile strength of rope in the dry and the wet series of five tests each*—Continued.

MACHINE-LAID ROPES MADE OF COMMERCIAL CORDAGE FIBERS.

Fiber.	Maximum variation from mean tensile strength.	
	Dry series.	Wet series.
	Per cent.	*Per cent.*
Musa textilis; grade "F" abacá rope, 31 millimeters in circumference	5	8
Musa textilis; grade "F" abacá rope, 15 millimeters in circumference	10	13
Musa textilis; grade "G" abacá rope, 26 millimeters in circumference	7	6
Musa textilis; grade "G" abacá rope, 16 millimeters in circumference	3	15
Agave cantala; maguey, grade Cebu No. 2, rope, 26 millimeters in circumference	8	11
Average	7	11

HAND-LAID ROPES MADE OF MISCELLANEOUS FIBERS.

Fiber.	Dry series.	Wet series.
Cocos nucifera; rope 50 millimeters in circumference	8	[d]12
Cocos nucifera; rope 44 millimeters in circumference	8	[d]2
Cocos nucifera; rope 24 millimeters in circumference	25	20
Corypha elata; buntal	11	10
Amomum sp	15	18
Anamirta cocculus	14	[a]10
Dendrocalamus merrillianus	29	19
Average	16	13

[a] Three tests only.
[b] No test made.
[c] Four tests only.
[d] Only two tests made and these are practically identical.

In Table XLI are tabulated the number of rope test specimens ruptured, together with the manner of their failure. Two hundred forty-eight dry specimens were broken, of which 122, or 49 per cent, failed in eye-splices. Of the 217 wet test pieces 78, or 36 per cent, ruptured in eye-splices.

Fifty-seven per cent of the dry, and 69 per cent of the wet, specimens that gave maximum tensile-strength values failed in the unspliced portion of the test pieces. Breaks in eye-splices do not necessarily imply that the various test specimens are faulty, abnormal, or low in value; for frequently the minimum values in both wet and dry specimens were obtained from those that failed in the unspliced portion of the rope between the eye-splices, whereas the maximum values were often obtained for pieces that ruptured in the eye-splices.

In the dry specimens the number of breaks and of maximum values from test pieces breaking in the eye-splices is about equal to the number of those obtained from test pieces that failed in the unspliced sections of the test specimens. However, wetting reduced considerably the number of specimens breaking in eye-splices and seemed to cause failure in the un-

TABLE XLI.—*Number of rope test specimens ruptured and the manner of their failure.*

[U = in the unspliced section; E = in an eye-splice.]

HANDMADE BAST-FIBER ROPES.

Fiber.	Number of tests averaged.		Specimens broken in eye-splices.		Occurrence of failure in specimen giving—			
					Maximum value.		Minimum value.	
	Dry.	Wet.	Dry.	Wet.	Dry series.	Wet series.	Dry series.	Wet series.
Abroma fastuosa (unretted)	5	5	2	1	U	U	U	U
Commersonia bartramia	5	5	4	1	U	U	E	U
Helicteres hirsuta	5	5	0	2	U	U	U	E
Kleinhovia hospita	5	5	0	2	U	U	U	U
Pterocymbium tinctorium	5	5	3	0	E	U	E	U
Pterospermum diversifolium	5	5	5	1	E	U	E	U
Sterculia crassiramea	5	5	1	3	U	U	U	E
Sterculia foetida	5	4	0	1	U	E	U	U
Sterculia oblongata	5	5	2	3	U	U	U	U
Sterculia stipularis	5	5	2	5	U	E	U	E
Bombycidendron vidalianum	5	5	1	2	U	U	U	U
Malachra fasciata	5	5	2	1	U	U	E	E
Sida acuta	5	4	3	3	U	U	E	E
Thespesia lampas	5	5	3	1	E	U	U	U
Urena lobata	5	5	4	2	E	U	E	U
Columbia blancoi	5	5	2	2	U	U	E	U
Corchorus olitorius	5	5	3	2	E	E	U	E
Grewia eriocarpa	5	5	2	3	E	E	E	E
Grewia bilamellata	5	5	1	0	U	U	U	U
Grewia multiflora	5	5	3	3	E	U	U	E
Allaeanthus glaber	5	5	4	2	E	E	U	U
Artocarpus communis; (young bast)	5	5	2	2	E	U	U	U
Ficus benjamina	5	5	2	0	U	U	E	U
Ficus forstenii	5	5	2	0	U	U	E	U
Ficus pachyphylla	5	5	1	2	U	E	U	E
Ficus palawanensis	5	5	1	1	E	U	U	E
Cordia cumingiana	5	5	3	0	E	U	U	U
Cordia myxa	5	5	2	1	E	E	U	U
Gnetum sp	5	5	0	1	U	U	U	U
Bombax ceiba	4	5	3	1	E	E	E	U
Trema orientalis	5	2	2	1	U	E	U	U
Goniothalamus amuyon	5	5	3	2	U	U	E	U
Total	159	155	[e]68	[f]51	(a)	(b)	(c)	(d)

[a] 19U, 59 per cent; 13E, 41 per cent.

[b] 23U, 72 per cent; 9E, 28 per cent.

[c] 20U, 63 per cent; 12E, 37 per cent.

[d] 22U, 69 per cent; 10E, 31 per cent.

[e] 42.7 per cent.

[f] 32.9 per cent.

TABLE XLI.—*Number of rope test specimens ruptured and the manner of their failure*—Continued.

MACHINE-LAID ROPES MADE OF COMMERCIAL CORDAGE FIBERS.

Fiber.	Number of tests averaged.		Specimens broken in eye-splices.		Occurrence of failure in specimen giving—			
					Maximum value.		Minimum value.	
	Dry.	Wet.	Dry.	Wet.	Dry series.	Wet series.	Dry series.	Wet series.
Musa textilis; grade "F" abacá rope, 31 millimeters in circumference	14	10	14	6	E	E	E	E
Musa textilis; grade "G" abacá rope, 26 millimeters in circumference	15	10	12	6	U	U	E	E
Agave cantala; grade Cebu No. 2	15	10	11	2	E	E	E	U
Total	44	30	[k] 37	[l] 14	(e)	(e)	(f)	(e)
HAND-LAID ROPES MADE OF MISCELLANEOUS PHILIPPINE FIBERS.								
Cocos nucifera; coir rope, 50 millimeters in circumference	5	4	2	0	E	U	U	U
Cocos nucifera; coir rope, 44 millimeters in circumference	8	4	5	1	U	U	E	E
Cocos nucifera; coir rope, 24 millimeters in circumference	12	6	2	3	U	U	U	U
Corypha elata; buntal rope, 22 millimeters in circumference	5	5	8	2	U	U	E	E
Amomum sp.	5	5	1	2	E	U	U	E
Anamirta cocculus	5	3	0		U	E	U	U
Dendrocalamus merrillianus	5	5	4	4	E	E	E	U
Total	45	32	[m] 17	[n] 13	(g)	(h)	(g)	(g)
Grand total	248	217	[o] 122	[p] 78	(q)	(r)	(s)	(t)

[e] 1U, 33 per cent; 2E, 67 per cent.

[f] 3E, 100 per cent.

[g] 4U, 57 per cent; 3E, 43 per cent.

[h] 5U, 71 per cent; 2E, 29 per cent.

[k] 84 per cent.

[l] 46.7 per cent.

[m] 37.8 per cent.

[n] 40.6 per cent.

[o] 49.3 per cent.

[p] 36 per cent.

[q] 24U, 57 per cent; 18E, 43 per cent.

[r] 29U, 69 per cent; 13E, 31 per cent.

[s] 24U, 57 per cent; 18E, 43 per cent.

[t] 27U, 64 per cent; 15E, 36 per cent.

spliced sections of a larger proportion of the specimens giving maximum values. On the other hand, the preponderance of minimum values is not found in those that broke in eye-splices. About half of the dry test pieces giving minimum values failed in the unspliced section of the test piece. As in the case of the maximum values, wetting had the effect of causing a still less number of breaks in eye-splices.

Machine-laid rope made of commercial cordage fibers gave very concordant results, the average maximum variations from the mean tensile strength in the dry and the wet specimens being 7 and 11 per cent, respectively. Handmade coir rope (coir is a filamentous fiber like abacá) also gives excellent agreement; this indicates that machine fabrication is not necessarily the main factor in determining whether the tensile-strength values will be concordant or not. Therefore, the failure of a test specimen in an eye-splice is normal and there can be no question as to the acceptability of such values. Apparently uniformity in tenacity values depends largely upon the nature of the fiber, and the irregular tensile-strength values must be attributed largely to the crude, nonuniform nature of the bast itself.

The summary of averages of the tensile-strength tests, breaking length, weight per unit length, elongation, girth, diameter, etc., of the test specimens is arranged by species in Table XLII.

SUMMARY

The averages of two series of tests on the tenacity of Philippine bast-fiber ropes are given; the one on air-dry specimens, and the other on specimens that had been immersed in fresh tap water for twenty-four hours. In order to show the relative strength of bast ropes, as compared with standard fiber cordage, a few tests of machine-laid abacá and maguey rope are given. A few results of tests of miscellaneous ropes made of material not coming under the classification of either bast or standard cordage fiber have been included also. A primitive wooden rope-laying apparatus is described and illustrated.

In Table III are recorded the mean tensile strengths of the dry bast ropes tested. Dry rope made of *Gnetum* sp. bast, having a mean circumference of 18 millimeters, heads the list with a maximum mean tensile strength of 773 kilograms per square centimeter (11,100 pounds per square inch). This value compares favorably with the values for "F" and "G" grades abacá rope. Rope made of coir fiber, which ranges in strength from 170 to 185 kilograms per square centimeter (2,420 to 2,640 pounds per square inch), ranks with the poorest basts.

In Table IV are recorded the mean tensile strengths of ropes that had been immersed for twenty-four hours in fresh tap water. Rope made of *Gnetum* sp. fiber still heads the series with even augmented tenacity. It will be noted that wetting has a marked influence upon, and generally causes a slight decrease in, the tensile strength of most bast ropes.

In Table V are recorded, in the order of their magnitude, the breaking lengths of the ropes tested, and the general order follows that of the relative tenacity. Of the bast ropes, the rope made of *Gnetum* sp. is the highest, with a breaking length of 8,450 meters (27,700 feet), which closely approaches the values of the various abacá ropes tested. Despite its light weight, rope made of coconut fiber, which is sometimes considered a standard cordage material, has a breaking length inferior to most of the bast-fiber ropes tested. The elongation of bast-fiber ropes is generally less than that of most standard cordage fibers. Wetting has the effect of increasing the mean elongation of nearly all of them. The minimum and maximum averages for dry and wet specimens are 6 and 16 per cent, and 9 and 25 per cent, respectively.

TABLE XLII.—*Summary of tensile-strength and other tests of Philippine fiber ropes, arranged by species.*

BAST-FIBER ROPES.

Scientific name.	Name most commonly used in the Ilocano provinces.	Mean tensile strength.							
		Dry.				Wet.[c]			
		Kilos.	*Pounds.*	*Kilos per sq. cm.*	*Pounds per sq. inch.*	*Kilos.*	*Pounds.*	*Kilos per sq. cm.*	*Pounds per sq. inch.*
Abroma fastuosa; rope made of crude strips of bast	Anabó	482	1,063	545	7,760	282	621	319	4,530
Abroma fastuosa; rope made of retted bast	do	157	345	643	9,100	(1)	(1)	(1)	(1)
Commersonia bartramia	Kakaag	382	843	392	5,580	259	570	266	3,780
Helicteres hirsuta	Kol-lokol-lot ti bao	345	761	438	6,230	311	685	396	5,620
Kleinhovia hospita	Bitnong	360	793	309	4,370	334	737	286	4,070
Pterocymbium tinctorium	Marakapas	435	959	381	5,420	496	1,093	435	6,180
Pterospermum diversifolium	Baroy	75.7	167	263	3,740	75.3	166	261	3,690
Sterculia crassiramea	Bannakalau	483	1,064	398	5,660	373	823	308	4,380
Sterculia foetida	Bangar	56.7	125	200	2,840	56.7	125	200	2,840
Sterculia oblongata	Sinaligan	382	842	398	5,650	279	615	291	4,130
Sterculia stipularis forma	Labnay	79.4	175	268	3,800	108	239	366	5,200
Bombycidendron vidalianum	Lusuban	199	438	630	8,940	148	327	468	6,670
Malachra fasciata	Bakembakes	135	298	637	9,030	115	253	543	7,700
Sida acuta	Tackimbaca	193	426	475	6,760	205	453	502	7,190
Thespesia lampas	Dal-dal-lupang	155	341	268	3,800	168	370	291	4,130
Urena lobata var. *scabruscula*[d]	Puriket	146	322	482	6,850	111	244	366	5,200
Columbia blancoi	Keddeng	347	765	302	4,270	352	776	306	4,340
Corchorus olitorius	Saluyot	165	364	503	7,130	118	260	360	5,100
Grewia eriocarpa	Bariw-an	102	225	394	5,630	98.8	218	381	5,450
Grewia bilamellata	Benglaren	124	274	320	4,570	69.8	154	180	2,570
Grewia multiflora	Alinau	321	708	376	5,360	283	624	332	4,730
Allaeanthus glaber	Bungon	231	509	231	3,290	253	557	253	3,590

Artocarpus communis[k]	Bakak	101	223	356	5,070	96.5	213	340	4,830
Artocarpus communis[j]	do	222	490	367	5,220	(l)	(l)	(l)	(l)
Ficus benjamina	Balete	156	343	480	6,830	153	338	471	6,700
Ficus forstenii	Puos or puspus	59.8	132	154	2,200	86.2	190	222	3,160
Ficus pachyphylla	Pasakla	150	330	464	6,600	176	388	544	7,760
Ficus palawanensis	Agamid	154	339	752	10,700	157	346	766	10,900
Cordia cumingiana	Maratarong	337	743	388	5,500	316	696	364	5,160
Cordia myxa	Anonang	144	318	324	4,610	117	257	263	3,730
Gnetum sp	Kaliat	166	366	773	11,100	217	478	1,000	14,500
Bombax ceiba	Bobor or taroktok	174	383	405	5,720	151	332	351	4,960
Trema orientalis	Arandong	62.6	138	134	1,920	122	268	262	3,720
Goniothalamus amuyon	Saguiat	141	311	345	4,940	120	264	293	4,180

[d] This rope sample was made of a mixture of *Urena lobata* and *Corchorus olitorius* basts in about equal proportions.

[j] Bast from old tree.

[k] Bast from young tree.

[l] No test made.

[o] Rope submerged in fresh tap water twenty-four hours before testing.

TABLE XLII.—*Summary of tensile-strength and other tests of Philippine fiber ropes, arranged by species*—Continued.

ROPES MADE OF MISCELLANEOUS PHILIPPINE FIBERS.

Scientific name.	Name most commonly used in the Ilocano provinces.	Mean tensile strength.							
		Dry.				Wet.[o]			
		Kilos.	*Pounds.*	*Kilos. per sq. cm.*	*Pounds per sq. inch.*	*Kilos.*	*Pounds.*	*Kilos per sq. cm.*	*Pounds per sq. inch.*
Musa textilis; grade "F" abacá[b]	Abacá	724	1,596	943	13,400	727	1,604	946	13,500
Do	do	151	333	974	13,800	143	316	923	13,100
Musa textilis; grade "G" abacá[b]	do	398	878	744	10,600	406	896	759	10,800
Do	do	157	345	1,110	15,700	166	366	1,180	16,700
Agave cantala; Cebu No. 2[b]	Maguey	322	709	739	10,400	284	626	651	9,220
Agave cantala[h]	do	146	322	408	5,850	(1)	(1)	(1)	(1)
Agave cantala[i]	do	122	270	288	4,080	(1)	(1)	(1)	(1)
Corypha elata[e]	Silag	403	887	232	3,300	(1)	(1)	(1)	(1)
Corypha elata[f]	Buntal	77.1	170	222	3,150	89.3	197	257	3,650
Cocos nucifera; coir[n]	Bonot	295	651	185	2,640	217	479	136	1,940
Cocos nucifera; coir[c]	do	222	490	170	2,420	191	420	146	2,070
Do	do	68.8	152	176	2,490	[a] 57.6	[a] 127	[a] 148	[a] 2,100
Dendrocalamus merrillianus	Bayog	378	834	237	3,380	285	628	179	2,540
Anamirta cocculus[m]	Labtang	192	424	149	2,120	142	313	110	1,570
Amomum sp	Agset or sag-et	89.8	198	349	4,950	83.5	184	325	4,600

[a] Strength after having been immersed in stagnant tap water twenty-one days.
[b] Machine-made rope; all other ropes are handmade.
[c] Rope made from fiber machine cleaned at the Bureau of Science.
[e] Rope made from the leaf of the buri palm.
[f] Rope made of the vascular fibers found in the petioles of the buri-palm leaf.
[h] Rope made at Santo Domingo, Ilocos Sur.
[i] Rope made at Sulvec, Ilocos Sur.
[1] No test made.
[m] Entire vine twisted into a three-strand rope.
[n] Rope made at Caoayan, Ilocos Sur, from salt-water retted coir.
[o] Rope submerged in fresh tap water twenty-four hours before testing.

BAST-FIBER ROPES.

Scientific name.	Name most commonly used in the Ilocano provinces.	Mean breaking length.		Average weight per unit length.		Average elongation at the instant of rupture.		Average girth of cord.		Average diameter of rope based on a circle having a circumference equal to girth of rope.	
						Dry.	Wet.				
		Meters.	*Feet.*	*Pounds per foot.*	*Grams per meter.*	*Per cent.*	*Per cent.*	*mm.*	*in.*	*mm.*	*in.*
Abroma fastuosa; rope made of crude strips of bast	Anabó	5,770	18,900	0.0562	83.7	[g] 12	[g] 13	36	1.42	11.5	0.45
Abroma fastuosa; rope made of retted bast	do	7,740	25,400	0.0136	20.2	(1)	(1)	19	0.75	6.1	0.24
Commersonia bartramia	Kakaag	4,070	13,300	0.0632	93.9	[g] 14	[g] 13	38	1.50	12.1	0.48
Helicteres hirsuta	Kol-lokol-lot ti bao	3,950	12,950	0.0587	87.4	[g] 13	[g] 13	35	1.38	11.2	0.44
Kleinhovia hospita	Bitnong	3,870	12,700	0.0625	92.9	[g] 13	[g] 13	39	1.54	12.4	0.49
Pterocymbium tinctorium	Marakapas	4,560	14,900	0.0642	95.4	[g] 10	[g] 12	42	1.66	13.4	0.53
Pterospermum diversifolium	Baroy	2,620	8,620	0.0194	28.9	11	15	21	0.83	6.7	0.26
Sterculia crassiramea	Bannakalau	5,050	16,600	0.0642	95.5	[g] 13	[g] 14	40	1.58	12.7	0.50
Sterculia foetida	Bangar	1,964	6,450	0.0194	28.8	6	10	22	0.87	7.0	0.28
Sterculia oblongata	Sinaligan	4,490	14,700	0.0572	85.1	[g] 13	[g] 14	38	1.50	12.1	0.48
Sterculia stipularis forma	Labnay	2,980	9,780	0.0179	26.6	7	10	22	0.87	7.0	0.28
Bombycidendron vidalianum	Lusuban	6,950	22,800	0.0192	28.6	12	14	22	0.87	7.0	0.28
Malachra fasciata	Bakembakes	7,580	24,800	0.0120	17.9	8	10	17	0.67	5.4	0.21
Sida acuta	Tackimbaca	5,770	18,900	0.0225	33.5	14	18	24	0.95	7.6	0.30
Thespesia lampas	Dal-dal-lupang	3,180	10,400	0.0327	48.7	9	13	30	1.18	9.6	0.38
Urena lobata var. *scabruscula* [d]	Puriket	6,180	20,300	0.0159	23.7	8	11	21	0.83	6.7	0.26
Columbia blancoi	Keddeng	3,510	11,500	0.0663	98.7	[g] 13	[g] 15	43	1.69	13.7	0.54
Corchorus olitorius	Saluyot	5,420	17,800	0.0205	30.5	8	10	22	0.87	7.0	0.28
Grewia eriocarpa	Bariw-an	5,050	16,600	0.0136	20.2	6	9	20	0.79	6.4	0.25

[d] This rope sample was made of a mixture of *Urena lobata* and *Corchorus olitorius* basts in about equal proportions.

[g] Gauge length, 100 centimeters; all other test pieces had a gauge length of 50 centimeters.

[1] No test made.

TABLE XLII.—*Summary of tensile-strength and other tests of Philippine fiber ropes, arranged by species*—Continued.

BAST-FIBER ROPES—Continued.

Scientific name.	Name most commonly used in the Ilocano provinces.	Mean breaking length.		Average weight per unit length.		Average elongation at the instant of rupture.		Average girth of cord.		Average diameter of rope based on a circle having a circumference equal to girth of rope.	
						Dry.	Wet.				
		Meters.	*Feet.*	*Pounds per foot.*	*Grams per meter.*	*Per cent.*	*Per cent.*	*mm.*	*in.*	*mm.*	*in.*
Grewia bilamellata	Benglaren	3,810	12,500	0.0219	32.6	11	11	24	0.95	7.6	0.30
Grewia multiflora	Alinau	3,660	12,000	0.0591	87.9	[g] 10	[g] 11	36	1.42	11.5	0.45
Allaeanthus glaber	Bungon	2,440	8,030	0.0635	94.4	[g] 13	[g] 25	39	1.54	12.4	0.49
Artocarpus communis[k]	Pakak	4,450	14,600	0.0153	22.8	11	15	19	0.75	6.1	0.24
Artocarpus communis[j]	do	4,560	14,900	0.0328	48.8	(1)	(1)	30	1.18	9.6	0.38
Ficus benjamina	Balete	5,030	16,500	0.0208	31.0	9	15	23	0.91	7.3	0.29
Ficus forstenii	Puos or puspus	1,600	5,260	0.0251	37.3	11	18	22	0.87	7.0	0.28
Ficus pachyphylla	Pasakla	4,930	16,200	0.0204	30.3	12	17	22	0.87	7.0	0.28
Ficus palawanensis	Agamid	6,230	20,400	0.0166	24.7	12	19	19	0.75	6.1	0.24
Cordia cumingiana	Maratarong	4,450	14,600	0.0508	75.6	[g] 16	[g] 16	38	1.50	12.1	0.48
Cordia myxa	Anonang	4,125	13,500	0.0235	34.9	11	14	25	0.99	7.96	0.31
Gnetum sp	Kaliat	8,450	27,700	0.0132	19.7	10	12	18	0.71	5.7	0.23
Bombax ceiba	Bobor or taroktok	4,620	15,150	0.0253	37.7	8	10	26	1.02	8.3	0.33
Trema orientalis	Arandong	1,420	4,660	0.0296	44.1	7	21	26	1.02	8.3	0.33
Goniothalamus amuyon	Saguiat	3,680	12,050	0.0258	38.4	9	13	29	1.14	9.2	0.36

[g] Gauge length, 100 centimeters; all other test pieces had a gauge length of 50 centimeters.

[j] Bast from old tree.

[k] Bast from young tree.

[1] No test made.

ROPES MADE OF MISCELLANEOUS PHILIPPINE FIBERS.

Musa textilis; grade "F" abacá [b]	Abacá	12,300	40,400	0.0395	53.8	[g] 13	[g] 18	31	1.22	9.9	0.39
Do	do	11,900	39,000	0.0085	12.7	8	12	15	0.59	4.8	0.19
Musa textilis; grade "G" abacá [b]	do	8,390	27,500	0.0319	47.5	[g] 16	[g] 19	26	1.02	8.3	0.33
Do	do	10,200	33,300	0.0104	15.4	13	15	16	0.63	5.1	0.20
Agave cantala; Cebu No. 2 [b]	Maguey	9,350	30,700	0.0231	34.3	[g] 12	[g] 17	26	1.02	8.3	0.33
Agave cantala [h]	do	3,750	12,300	0.0262	38.9	(l)	(l)	23	0.91	7.3	0.29
Agave cantala [i]	do	3,810	12,500	0.0216	32.2	(l)	(l)	25	0.99	7.96	0.31
Corypha elata [e]	Silag	3,630	11,900	0.0746	111.2	[g] 18	(l)	47	1.85	14.9	0.59
Corypha elata [f]	Buntal	3,700	12,100	0.0140	20.8	14	18	22	0.87	7.0	0.28
Cocos nucifera; coir [n]	Bonot	2,620	8,610	0.0756	112.5	[g] 36	[g] 38	50	1.97	15.9	0.63
Cocos nucifera; coir [c]	do	2,730	8,950	0.0548	81.5	39	42	44	1.73	14.0	0.55
Do	do	3,550	11,650	0.0130	19.4	30	32	24	0.95	7.6	0.30
Dendrocalamus merrillianus	Bayog	3,800	12,450	0.0669	99.6	[g] 15	[g] 16	46	1.81	14.6	0.58
Anamirta cocculus [m]	Labtang	3,200	10,500	0.0404	60.1	[g] 19	[g] 14	44	1.73	14.0	0.55
Amomum sp	Agset or sag-et	5,530	18,150	0.0109	16.2	9	10	20	0.79	6.4	0.25

[b] Machine-made rope; all other ropes are handmade.

[c] Rope made from fiber machine cleaned at the Bureau of Science.

[e] Rope made from the leaf of the buri palm.

[f] Rope made of the vascular fibers found in the petioles of the buri-palm leaf.

[g] Gauge length, 100 centimeters; all other test pieces had a gauge length of 50 centimeters.

[h] Rope made at Santo Domingo, Ilocos Sur.

[i] Rope made at Sulvec, Ilocos Sur.

[l] No test made.

[m] Entire vine twisted into a three-strand rope.

[n] Rope made at Caoayan, Ilocos Sur, from salt-water retted coir.

ILLUSTRATIONS

PLATE I

FIG. 1. Laying a three-strand rope having a mean girth of 30 millimeters, made of crude strips of *Artocarpus communis* bast at Sappaac, Abra, obtained from the trunk of an old tree.

2. Heavy hardwood rope-laying apparatus (*pagtalian,* Ilocano) used in Caoayan, Ilocos Sur, for making large-sized mooring ropes, together with two coils of rope made therewith. One coil of rope is made of maguey (*Agave cantala*) and the other of a species of bamboo (*Dendrocalamus merrillianus*).

PLATE II

FIG. 1. Laying a three-strand rope having a mean girth of 19 millimeters, made of retted *Abroma fastuosa* bast at Sappaac, Abra. The view shows the triple-crank end of the crude rope-laying apparatus with strands still separate. In the foreground are two men holding spun and unspun bast.

2. Form of specimen used for making tensile-strength tests of Philippine bast-fiber ropes.

PLATE III. PHILIPPINE BAST-FIBER ROPES

FIG. 1. Rope having a mean girth of 19 millimeters, made of retted *Abroma fastuosa* bast.

2. Rope having a mean girth of 36 millimeters, made of crude (unretted) strips of *Abroma fastuosa* bast.

3. Rope having a mean girth of 38 millimeters, made of crude strips of *Commersonia bartramia* bast.

4. Rope having a mean girth of 35 millimeters, made of crude strips of *Helicteres hirsuta* bast.

5. Rope having a mean girth of 39 millimeters, made of crude ribbons of *Kleinhovia hospita* bast.

6. Rope having a mean girth of 42 millimeters, made of crude strips of *Pterocymbium tinctorium* bast.

7. Rope having a mean girth of 21 millimeters, made of crude strips of *Pterospermum diversifolium* bast.

8. Rope having a mean girth of 40 millimeters, made of crude ribbons of *Sterculia crassiramea* bast.

9. Rope having a mean girth of 22 millimeters, made of *Sterculia foetida* bast.

10. Rope having a mean girth of 38 millimeters, made of crude ribbons of *Sterculia oblongata* bast.

11. Rope having a mean girth of 22 millimeters, made of crude strips of *Sterculia stipularis* bast.

12. Rope having a mean girth of 22 millimeters, made of crude strips of *Bombycidendron vidalianum* bast.

13. Rope having a mean girth of 17 millimeters, made of retted *Malachra lineariloba* bast.

14. Rope having a mean girth of 24 millimeters, made of retted *Sida acuta* bast.
15. Rope having a mean girth of 30 millimeters, made of crude *Thespesia lampas* bast.

PLATE IV. PHILIPPINE BAST-FIBER ROPES

FIG. 1. Rope having a mean girth of 21 millimeters, made of a mixture, in about equal proportions, of crude strips of *Urena lobata* and *Corchorus olitorius* bast.
2. Rope having a mean girth of 43 millimeters, made of crude strips of *Columbia blancoi* bast.
3. Rope having a mean girth of 22 millimeters, made of crude strips of *Corchorus olitorius* bast.
4. Rope having a mean girth of 24 millimeters, made of crude strips of *Grewia bilamellata* bast.
5. Rope having a mean girth of 20 millimeters, made of crude strips of *Grewia eriocarpa* bast.
6. Rope having a mean girth of 36 millimeters, made of crude strips of *Grewia multiflora* bast.
7. Rope having a mean girth of 39 millimeters, made of crude strips of *Allaeanthus glaber* bast.
8. Rope having a mean girth of 19 millimeters, made of crude strips of young *Artocarpus communis* bast.
9. Rope having a mean girth of 30 millimeters, made of crude strips of old *Artocarpus communis* bast.
10. Rope having a mean girth of 23 millimeters, made of crude strips of *Ficus benjamina* bast.
11. Rope having a mean girth of 22 millimeters, made of crude strips of *Ficus forstenii* bast.
12. Rope having a mean girth of 22 millimeters, made of crude strips of *Ficus pachyphylla* bast.
13. Rope having a mean girth of 19 millimeters, made of crude strips of *Ficus palawanensis* bast.

PLATE V. PHILIPPINE BAST- AND MISCELLANEOUS-FIBER ROPES

FIG. 1. Rope having a mean girth of 38 millimeters, made of crude strips of *Cordia cumingiana* bast.
2. Rope having a mean girth of 25 millimeters, made of crude strips of *Cordia myxa* bast.
3. Rope having a mean girth of 18 millimeters, made of crude strips of *Gnetum* sp. bast.
4. Rope having a mean girth of 26 millimeters, made of crude strips of *Bombax ceiba* bast.
5. Rope having a mean girth of 26 millimeters, made of crude strips of *Trema orientalis* bast.
6. Rope having a mean girth of 29 millimeters, made of crude strips of *Goniothalamus amuyon* bast.
7. Rope (two strands only) having a mean girth of 46 millimeters, made of a species of bamboo (*Dendrocalamus merrillianus*).
8. Rope having a mean girth of 44 millimeters, made of the entire stem of a vine (*Anamirta cocculus*).

9. Rope having a mean girth of 50 millimeters, made of coir (fiber extracted from the husk of the fruit of the coco palm, *Cocos nucifera*).
10. Rope having a mean girth of 47 millimeters, made of the leaf of the buri palm (*Corypha elata*).
11. Rope having a mean girth of 22 millimeters, made of the vascular fibers (buntal) found in the petioles of the buri palm (*Corypha elata*).
12. Rope having a mean girth of 20 millimeters, made of strips of *Amomum* sp. bast.

TEXT FIGURES

FIG. 1. Typical cross-sectional profiles of ropes tested. Actual size.
  - *a*, rope made of *Cordia cumingiana* bast.
  - *b*, rope made of *Kleinhovia hospita* bast.
  - *c*, rope made of split bamboo (*Dendrocalamus merrillianus*).
  - *d*, rope made of "F" grade abacá (machine laid).

2. Showing the twist of two-, three-, and four-strand ropes, respectively.

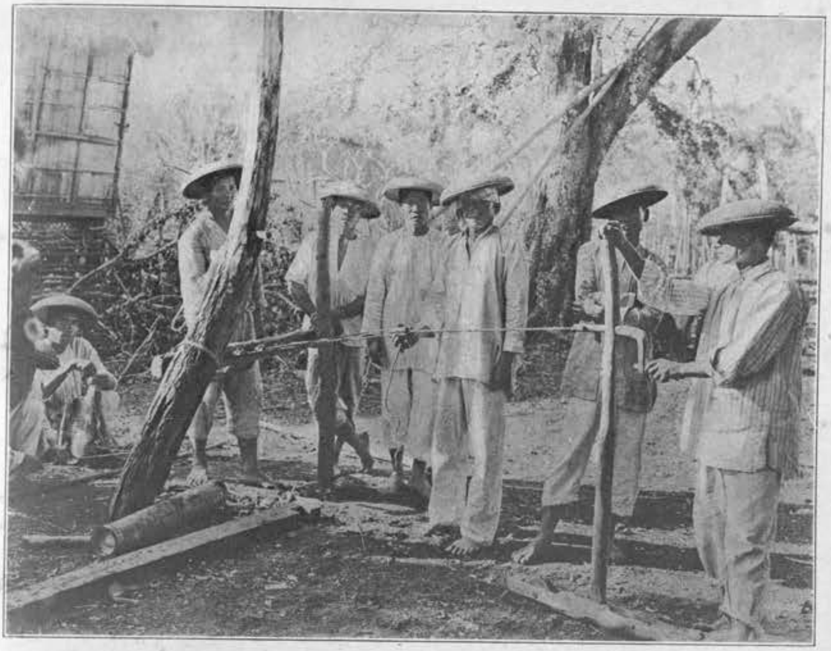

Fig. 1. Laying a three-strand rope.

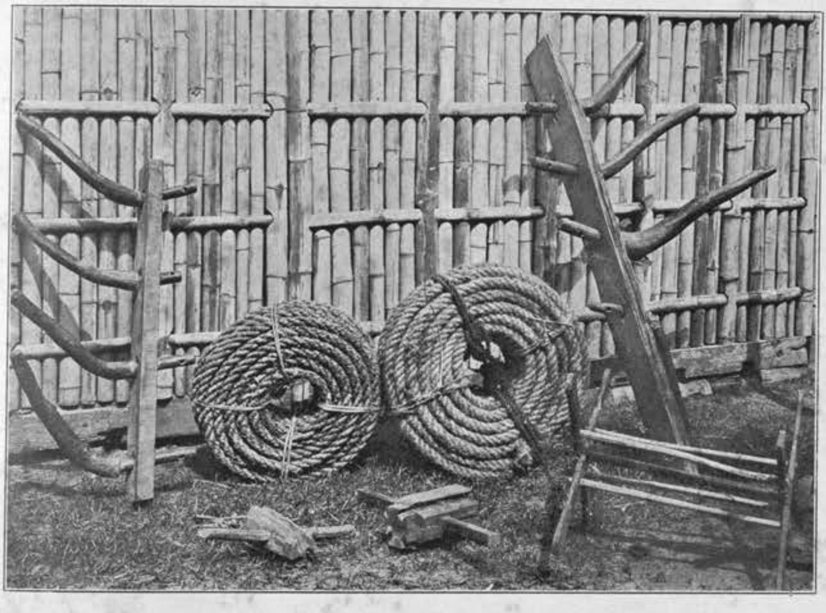

Fig. 2. Rope-laying apparatus.

PLATE I.

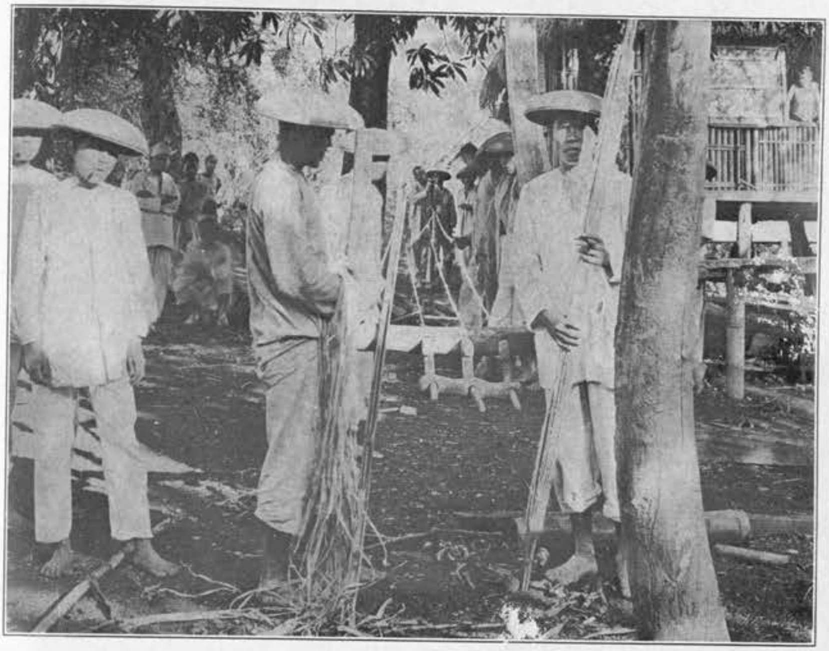

Fig. 1. The triple-crank end of the crude rope-laying apparatus.

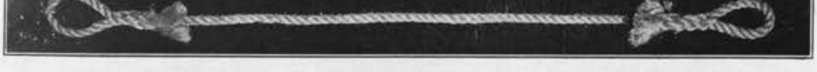

Fig. 2. Form of specimen used for making tensile-strength tests of Philippine bast-fiber ropes.

PLATE II.

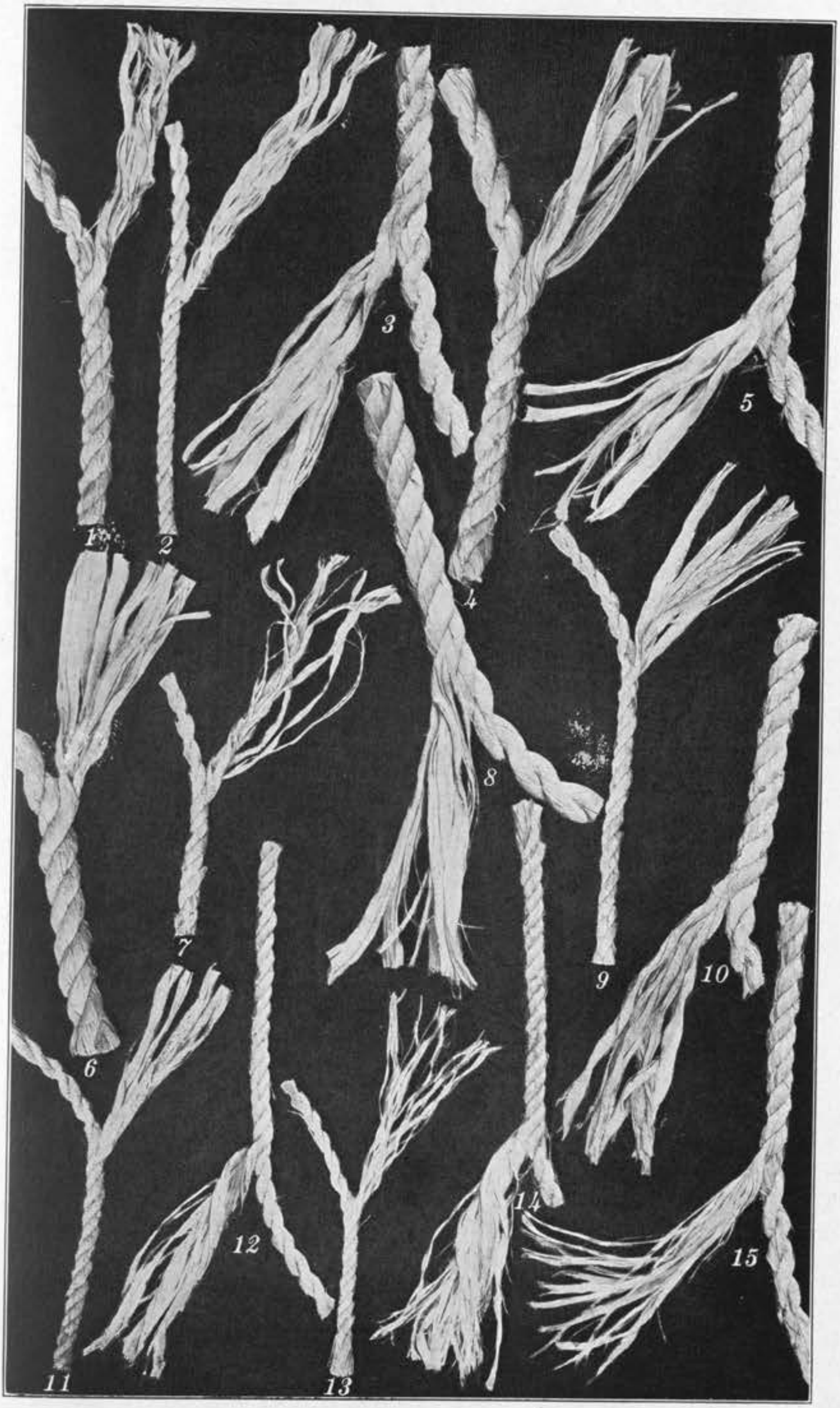

PLATE III. SAMPLES OF PHILIPPINE ROPES.

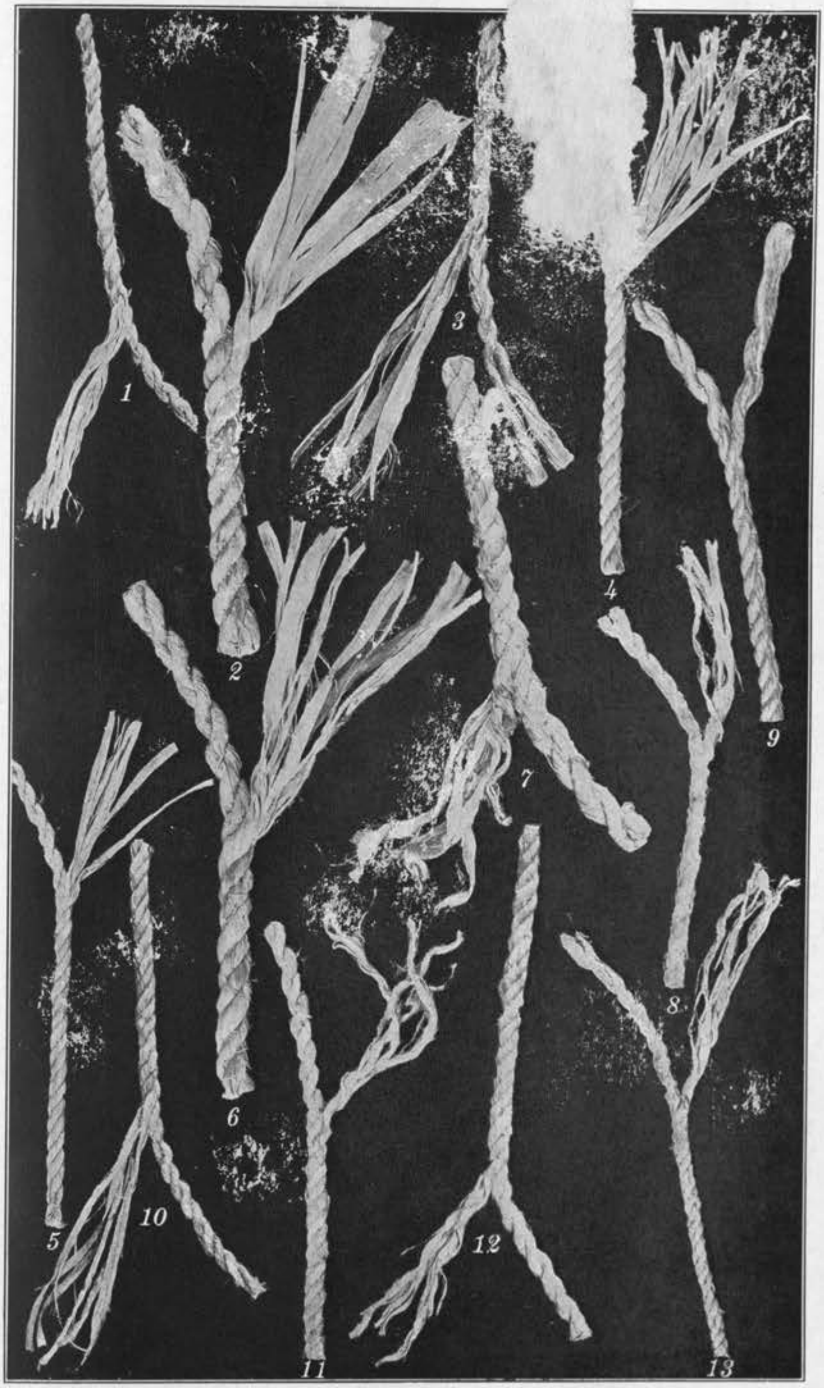

PLATE IV. SAMPLES OF PHILIPPINE ROPES.

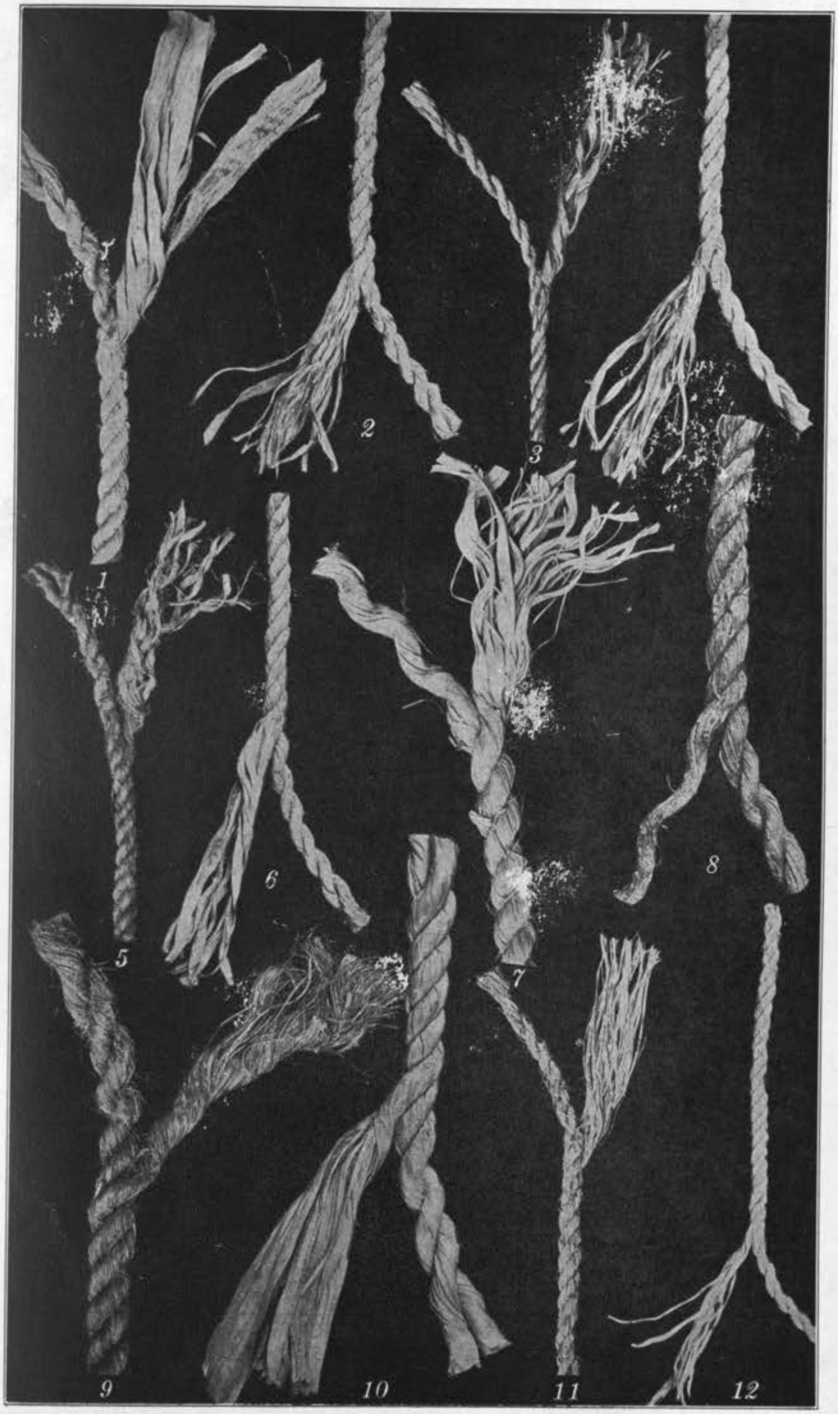

PLATE V. SAMPLES OF PHILIPPINE ROPES.

PINK DISEASE OF CITRUS

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SEVEN PLATES AND TWO TEXT FIGURES

During field work in 1917 an apparently serious stem and branch disease of citrus trees was discovered. Subsequent and more extended observation has indicated that the disease may cause the death of the affected branches or even of the whole tree. The spread of the disease and subsequent destruction of the trees during the rainy season was found to be very rapid. Specimens of diseased material in various stages were collected, and examination showed the organism responsible to be the previously well-described *Corticium salmonicolor* B. & Br.[2] Though this species of *Corticium* is known to cause very serious diseases of *Hevea brasiliensis* (HBK) Muell., *Theobroma cacao* Linn., *Coffea* sp., *Thea* sp., and other plants in the Orient, and has previously been reported upon *Citrus*, it has apparently not been known to cause an important disease of the latter host. Since the disease at present appears to be localized in its occurrence and as its spread over the Islands may involve serious damage not only to *Citrus* but also to cacao, coffee, rubber, and possibly other plants, it has seemed desirable to present certain data regarding the occurrence, appearance, and means of control of *Corticium*. Photographs of the various stages on *Citrus* are also presented, so that this disease may be recognized and the necessary measures applied for its control or eradication before it becomes widely distributed over the Philippine Islands. The name pink disease is commonly accepted by rubber planters throughout British Malaya and elsewhere as denoting the disease caused by *Corticium salmonicolor* B. & Br. This term is descriptive of the commonest form taken by the fungus and, as its use seems acceptable, it is continued here. Although *Corticium* has been thoroughly studied by us, no pretension is made that this paper contributes anything to the excellent studies on the morphology of the fungus already published by Rant, Brooks and Sharples, and others.

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[1] The writers wish to express their appreciation to Mr. E. Bateson, director of agriculture and mycologist for the Government of British North Borneo, for assistance and many courtesies extended to the junior writer, while on a recent visit to that country. The senior writer is indebted to Col. Adriano Hernandez, director, and Mr. S. Apostol, chief, division of plant industry, Philippine Bureau of Agriculture, for their kindness in making available to him opportunities for field work. He wishes to thank also Dr. Alvin J. Cox, former director, and Mr. E. D. Merrill, botanist, of the Philippine Bureau of Science, for many courtesies and the facilities of the botanical laboratories of that bureau.

[2] The identification of *Corticium salmonicolor* B. & Br. is based, not only upon a careful study of the organism and a comparison with the published descriptions and figures, but also upon comparison of material of *Corticium salmonicolor* B. & Br. collected upon *Hevea brasiliensis* (HBK) Muell. and on *Annona* sp. in British North Borneo where an opportunity was found to observe pink disease as it occurs in the field on *Hevea brasiliensis* (HBK) Muell., *Hibiscus* sp., and *Annona* sp.

HISTORY

Corticium salmonicolor B. & Br. apparently first attracted attention about 1897 when it appeared as a disease of coffee in Malaya. Specimens sent to Kew were described by Massee[3] as a new species and genus of *Fungi imperfecti* which he named *Necator decretus* Massee. In 1901 Zimmermann,[4] working on the disease on coffee in Java, described the organism as *Corticium javanicum* Zimm. In 1904 Ridley[5] mentioned a specimen of a fungus occurring upon *Hevea* that had been sent from Sandakan, apparently to be referred to this species, and in 1905[6] he reported the disease on two estates in the Malay Peninsula. Material sent to Kew was determined by Massee, this time as *Corticium calceum* Fr., a harmless and widely distributed species of Europe and America. In 1906 it was also found by Petch[7] to attack *Hevea* in Ceylon and southern India, and was recorded as *Corticium javanicum* Zimm. In 1909 Gallagher[8] reported *Corticium zimmermanni* Sacc. & Syd., which is a synonym of *Corticium salmonicolor* B. & Br., to be associated with a disease of rubber trees in Malaya. Petch[9] showed that material of this fungus was collected by Thwaites in Ceylon and was named

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[3] Kew Bull. (1898) 119.

[4] Centralbl. f. Bakt. Abth. 2, 7 (1901) 146.

[5] Agr. Bull. Straits & Fed. Malay States 3 (1904) 174.

[6] Agr. Bull. Straits & Fed. Malay States 4 (1905) 423.

[7] Report of Gov. Mycologist Ceylon (1906).

[8] Bull. Dept. Agr. F. M. S. 6 (1909).

[9] Petch, T., Physiology and Diseases of Hevea brasiliensis. London (1911) 209.

Corticium salmonicolor by Berkeley and Broome[10] in 1873; as this name has undoubted priority over all other names proposed, it must be used for the species.

Rant[11] has described the disease known as "djamoer oepas" (poison fungus) in Java, caused by *Corticium javanicum* Zimm., and has listed one hundred forty-one wild and cultivated plant species attacked by the fungus; among these are *Citrus* sp. and *Murraya exotica* Linn. Inoculation experiments made by Rant proved for the first time the identity of *Necator decretus* Massee as a form of *Corticium javanicum* Zimm. He also published a number of very good figures. In 1914 Brooks and Sharples[12] gave the history of the disease in the Malay Peninsula together with a description of the life history of the fungus and suggestions for treatment. In 1908 von Faber[13] reported its occurrence on coffee in the Cameroons. It has also been reported to our knowledge from Burma, Sumatra, Borneo, southern India, the Caucasus, and Formosa.

From a study of the history of the disease we find it to be very widely distributed throughout the eastern Tropics, and to occur upon a very large number of economic and wild plants. In 1900 the disease was practically unknown. Sharples[14] stated that in 1912 the fungus causing pink disease was known in only three small centers in Malaya, but by 1914 it had spread over practically the whole peninsula. One of us on a recent visit to British North Borneo found the disease to be very common on rubber in that country, where it would undoubtedly cause serious financial losses if control measures were not applied.

CORTICIUM IN THE WEST INDIES

A disease of cacao, lime, and other economic plants has been reported from the West Indies. It appears to have been long known as pink disease and was supposed to be due to a *Corticium;* however, it was believed to be a different species from that known in the East and was identified as *Corticium lilacino-fuscum* B. & C., a species described from temperate North America. Stockdale[15] calls attention to the existence of a similar disease in the East, but does not suggest the possibility that the organisms may be identical. Petch[16] appears to have been the first to suggest the identity of the organism causing pink disease in the two regions. Though not all of the literature relating to the disease occurring in the West Indies is available here, we note that recently Stevenson[17] has reported *Corticium salmonicolor* B. & Br. as the cause of a disease of *Citrus* in Porto Rico. The determination of the organism is credited to Doctor Burt, of the Missouri Botanic Garden.

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[10] Journ. Linn. Soc. Bot. 14 (1873) 71.

[11] Bull. Jardin Bot. Buitenzorg 4 (1912) 1–50, *f. 1–14.*

[12] Bull. Dept. Agr. F. M. S. 21 (1914).

[13] Centralbl. f. Bakt. Abth. 2, 21 (1908) 112.

[14] Kew Bull. (1917) 227.

[15] West Indian Bull. 9 (1908) 178.

OCCURRENCE OF CORTICIUM SALMONICOLOR B. AND BR. IN THE PHILIPPINES

Corticium salmonicolor B. & Br. has been found only recently in the Philippines, and the supposition seems justified that it is of recent introduction here. It was first collected in the fall of 1917 at Novaliches, near Manila, on *Annona* sp. Since that time it has been found at Los Baños, Laguna Province, and abundantly at Lamao, Bataan Province. The Lamao experiment station is the center of plant introduction and distribution in the Philippines, and plant materials are known to have been shipped from Lamao to both Novaliches and Los Baños. It seems very likely that *Corticium salmonicolor* B. & Br. was brought to Lamao on some plant introduced from another part of the Orient; for, while the fungus flora of the Philippines is far from being fully known, it seems very unlikely that botanical collectors and agricultural inspectors would have overlooked so conspicuous and destructive a fungus as *Corticium*—one likely to occur upon a very large number of hosts—had it existed in the Philippines for any considerable period.

As *Corticium* is very destructive to *Hevea brasiliensis* in other parts of the Orient, it is interesting to note that apparently it has not made its appearance on this host in the Philippines. The junior writer, while visiting the Basilan Rubber Plantation in November, 1917, made a careful survey of the estate for pink disease, but none was discovered. While Para rubber is cultivated in other parts of the Philippines, the Basilan plantation is the oldest and most accessible, and probably the one most likely to be infected through the introduction of young plants from Malaya. In the Philippines, *Corticium salmonicolor* B. & Br. has been collected only upon cultivated species, never upon naturally occurring plants.

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[16] Circulars & Agr. Journ. Roy. Bot. Gard. Ceylon 4 (1909) 189.

[17] Stevenson, John A., Fifth Report of the Board of Commissioners of Agriculture of Porto Rico (1915–1916) 43, 44.

DESCRIPTION OF THE DISEASE ON CITRUS

The first stage of the disease appears to be a slight gumming (Plate II, fig. 1, Plate IV, fig. 2), similar in many ways to the gumming which is produced coincident with many other injuries to the bark of *Citrus*. At this stage the bark seems dry and very hard, and it adheres closely to the wood. Often longitudinal cracks form in the bark at the same time with the gumming.

Usually the first appearance of the fungus is in the form of pustules, which push through the hardened bark (Plate I, fig. 1, Plate II, fig. 1). These pustules are dirty white to pinkish in color, usually 1 millimeter or less in diameter, and rather irregular in shape when observed under the hand lens; so far as known, they are sterile. These pustules appear to be the "Höckerchen" form described by Rant. Following the pustule stage, or sometimes occurring without any appearance of it, there is a formation of the mycelium of the fungus over the surface of the branch. This mycelium spreads and extends over the entire lesion (Plate IV, fig. 1, Plate III), forming a pink incrustation, which varies somewhat in shade but perhaps typically approaches most closely the "orange-pink" of Ridgway's[18] nomenclature. This color is the most striking characteristic of the fungus (Plate I). The incrustation is at first almost entirely smooth and of a velvety appearance, but with age it becomes roughened and broken up into patches, passing through transitional stages of color until it finally fades out to a dirty white. The mycelium advances up and down the branch as a characteristically delicate, smooth, fan-shaped white mycelium (Plate II, fig. 2).

In some cases, upon cutting through the bark beneath the actively advancing mycelium, no visible effect of the fungus is found even though the mycelium on the surface has advanced considerably beyond the cut; in others the bark is shown to have a watery, darkened, greenish appearance; while in still other cases the affected area extends beyond the limits of the surface mycelium. This variation may perhaps be explained by different seasonal conditions. As the disease advances, the watery appearance of the bark passes off, and the tissue becomes still darker in color and presents a dried-out appearance. The bark at this stage is a dry mass of shredded fibers, running longitudinally with the branch; the last condition seems typical of the effect of *Corticium*.

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[18] Ridgway, Robert, Color Standards and Color Nomenclature. Washington (1912) *pl. 2.*

On *Citrus* the outermost layers of the wood become discolored to a light brown. The extent of this brown tissue, however, is small in comparison with the area covered by the surface mycelium of the fungus, and the discoloration of tissue has never been observed to extend deep into the wood. Brooks and Sharples, in their study of the disease on rubber, found that the fungus hyphae followed the medullary rays well into the tissue.

The ultimate effect of the growth of the fungus is the stoppage of the water conduction, followed by the wilting of the leaves and the ultimate death of the affected limb. This last stage takes place very rapidly; frequently the leaves wilt, yellow, and drop within a period of five days. Small twigs, main branches, or even trunks of trees are attacked (Plate VI, fig. 1, Plate VII, fig. 2). It has never been observed on roots. The susceptibility of young and old trees seems to be equally great. The accompanying photographs probably show these stages much more clearly than can a written description.

Pink disease has been found upon the following horticultural varieties of *Citrus* species:

Citrus nobilis Lour.: Tizon, Kishiu, Suntara Nagpur.
Citrus sinensis Osbeck: Native cajel, Pineapple orange, Washington navel, Mediterranean, Valencia, White Siletta, Jaffa, St. Michael, Sawyer's navel, Navelencia.
Citrus aurantifolia Swingle: Tahiti, West Indian, Dayap.
Citrus limonia Osbeck: Valencia, Clark, Villa Franca, Messina, Belair, Lisbon.
Citrus aurantium Linn.: Seville.
Citrus maxima Merr. (*C. decumana* Linn.): Marsh, Triumph.
Citrus medica Linn. var. *sarcodactylis*.
Citrus hystrix DC.
Citrus micrantha Wester.
Citrus webberi Wester var. *montana* Wester.
Citrus species: Natsumikan.
Citrus hybrid: Tangelo, Sampson.

Feronia elephantum Corr. and *Murraya exotica* Linn., the genera of which are closely related to *Citrus*, have also been observed as hosts of *Corticium salmonicolor* B. & Br. in the Philippines. The omnivorous character of the fungus and the diversity of *Citrus* varieties attacked by *Corticium* seem to indicate that the occurrence of species or varieties of *Citrus* resistant to the disease is highly improbable.

DISSEMINATION OF THE FUNGUS

Very little is known about the means of dissemination of the fungus. Our observations upon the pustule, or "Höckerchen," stage have always shown it to be sterile. We have always observed the pink incrustation, which is the most noticeable stage of the fungus, to be sterile upon *Citrus*. Brooks and Sharples report and figure basidiospores upon the pink incrustation formed on rubber, but we have not observed them on the incrustation as it occurs upon *Citrus*.

Plate II, figs. 3 and 4, show the gross appearance of the stage first described by Massee as *Necator decretus*. This stage is found very abundantly on *Citrus* during the early months of the rainy season, usually upon wood that has been previously killed by the fungus. It is conspicuous for its bright orange color (bitter-sweet orange of Ridgway), very distinct from the pink color of the sterile mycelium of the fungus. Irregularly shaped, thin-walled spores are formed abundantly in this stage; and these spores would appear to be the principle means of dissemination of the fungus, at least over any considerable distance. This fact assumes a bearing on the methods of control, since it indicates the value of the removal of all twigs and branches affected with the disease before the appearance of the *Necator* stage. The *Necator* stage as it occurs on rubber has been well figured and described by Brooks and Sharples; and, in general, our observations of this stage on *Citrus* confirm their conclusions.

CONTROL EXPERIMENTS

In the fall of 1917, in connection with experiments in the control of citrus canker conducted at Lamao experiment station by the senior author, control methods against *Corticium* were also taken up. The orchards selected at Lamao for the citrus-canker experiments were so badly affected with pink disease that control measures were desirable in order that they might be maintained in good condition.

In the past, control measures against pink disease have been for the most part based upon the removal of affected tree parts, followed by disinfection. A number of disinfection methods have been practiced, probably the most commonly employed being the application of tar. Van Hall[19] suggests carbolineum as a disinfectant, and experiments in Malaya with other similar compounds are reported as being successful. Painting with a Bordeaux paste has also been recommended by a number of writers.

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[19] Van Hall, C. J. J., Cocoa. Macmillan & Co. Ltd., London (1914) 252.

Butler[20] writes that, in India, the application of Bordeaux mixture, 6–4–45, to the parts of Para rubber trees most susceptible to attack by pink disease has resulted in a reduction of the disease of from 50 to 75 per cent. The mixture was applied with a brush around the forks, for a foot or two down the stem, and up the branches. Two or three applications during the year appear to have produced the most satisfactory results. Butler states that over 200,000 trees were treated at a cost varying from 1 to 2 rupees an acre (about 1.65 to 3.30 pesos per hectare).

With reference to the practice of spraying as a preventive and remedial measure for pink disease, Petch[21] states that applications of Bordeaux, 5–5–45, against pink disease on cacao resulted favorably. His statement is but a brief mention of fact in connection with another subject, and he does not give his spraying data. Bancroft[22] has also recommended the practice of spraying without, however, giving his experimental data. So far as we know, the results discussed in this paper constitute the first experimental evidence of the value of spraying practices against pink disease.

Orchard A at the Lamao station, which consists of various horticultural varieties and species of *Citrus*, was the most badly affected by pink disease and the control-experiment data and results for this orchard are presented in the following pages. The diagram (fig. 1) shows the position of the trees and the rows in the orchard, and also indicates the location of the cases of pink disease existing in October, 1917.

The orchard was divided into plats as follows: Rows 1, 2, 3, 4, 5, 6, in Plat I; rows 7, 8, 9, in Plat II; rows 10, 11, 12, in Plat III; rows 13, 14, 15, in Plat IV; rows 16, 17, 18, 19, 20, in Plat V. These plats were treated as follows:

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[20] Butler, E. J., Fungi and Disease in Plants. Thacker, Spink & Co., Calcutta (1918) 505.

[21] Petch, T., Physiology and Diseases of Hevea brasiliensis. London (1911) 212.

[22] Bull. Dept. Agr. F. M. S. 1 (1912) 218.

TREATMENT OF ORCHARD A, LAMAO EXPERIMENT STATION

Plat I, rows 1, 2, 3, 4, 5, and 6.
- October, 1917: Limbs affected with pink disease pruned out.
- November 28: Lime sulphur.
- January 10: Neutral Bordeaux.
- May 31, 1918: Lime sulphur (change necessitated by increase of scale insects).
- June 25, 1918: Neutral Bordeaux.
- It was the original intention to continue the application of neutral Bordeaux through the entire period of the control experiments, but the increase of scale insects made changes to lime sulphur necessary.

Plat II, rows 7, 8, and 9.
- Neither pruning nor spraying was employed in this plat, the trees consisting of a check on the treated plats.

Plat III, rows 10, 11, and 12.
- October, 1917: Limbs affected with pink disease pruned out.
- November 28: Formalin 1–100.
- December 1: Formalin 1–75.
- December 6: Lime sulphur plus formalin 1–80.
- January 9, 1918: Neutral Bordeaux plus formalin 1–100.
- May 31: Lime sulphur.
- June 24: Lime sulphur.
- July 29: Lime sulphur.
- It was originally the intention to spray this plat entirely with lime sulphur; the applications of formalin, however, were employed because of the citrus canker experiments, while the application of neutral Bordeaux was made because no lime sulphur was available.

Plat IV, rows 13, 14, and 15.
- October, 1917: Pruned for *Corticium*.
- November 28: Formalin 1–100.
- December 6: Lime sulphur plus formalin 1–80.
- January 9, 1918: Neutral Bordeaux.
- May 31: Lime sulphur.
- June 26: Bordeaux 4–4–50.
- The changes from Bordeaux to lime sulphur and formalin were necessitated by the increase in scale insects and developments in the citrus canker work.

Plat V, rows 16, 17, 18, 19, and 20.
- The trees in this plat were neither sprayed nor pruned.

When pruning is mentioned it means that the trees of the plat indicated were gone over thoroughly to locate each case of the disease. Every affected limb was cut back far enough beyond the extent of the fungus to avoid all possibility of the fungus remaining in the unpruned portions. After each cutting the wound and the pruning implements were disinfected with a 2 per cent formalin solution. Subsequently each wound was painted with white lead.

In August, 1918, notes were made of the cases of pink disease in the orchard. The diagram, fig. 2, shows the number and location of diseased trees at that date.

DISCUSSION OF RESULTS

The text figures (figs. 1 and 2), showing the orchard with distribution of the spray plats, indicate perhaps most clearly the control obtained. To summarize, however:

In October, 1917, there were upon Plats I, III, and IV twenty-six trees affected with pink disease. At the same time in the unsprayed plats, II and V, there were fifteen cases of pink disease.

In August, 1918, the middle of the warm rainy season, no case was found in pruned and sprayed Plats I, III, and IV, the results amounting to effective and complete control. In untreated Plats II and V the fifteen cases of pink disease had increased to eighteen cases, in addition to which two trees, recorded in 1917 as having pink disease, had been killed as a result of the attacks by the disease.

The junior writer has observed control attempts on rubber in British North Borneo by pruning and disinfection methods alone. Such attempts appeared to give fairly satisfactory results without the accompanying spraying. However, the value of spraying is demonstrated by several cases observed at the Lamao orchard. In September tree 6, row 10, of this orchard was badly affected and nearly girdled with pink disease on the trunk. Because it was a large, valuable tree the station superintendent did not wish to have it entirely destroyed; and in deference to his wishes the tree was left, although its recovery appeared very improbable. Nevertheless, at every spraying period this lesion was given a strong application of the fungicide. In the last observation, August, 1918, the tree was in fine growing condition, and although in the middle of the rainy season the mycelium had not reappeared.

A similar experience was had with tree 8, row 11, exhibiting a very bad case of pink disease on the trunk and forks, where spraying resulted in the complete recovery of the tree. Trees in the unsprayed rows that showed similar attacks were killed within a short time.

Very similar results on rubber are reported by Richards[23] as having been obtained in the Federated Malay States by painting

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[23] Richards, R. M., Diseases of the leaves and stem of Hevea brasiliensis in the Malay Peninsula, *Proc. First Agr. Conference Malaya*, Kuala Lumpur (April 25, 1917) 45–47.

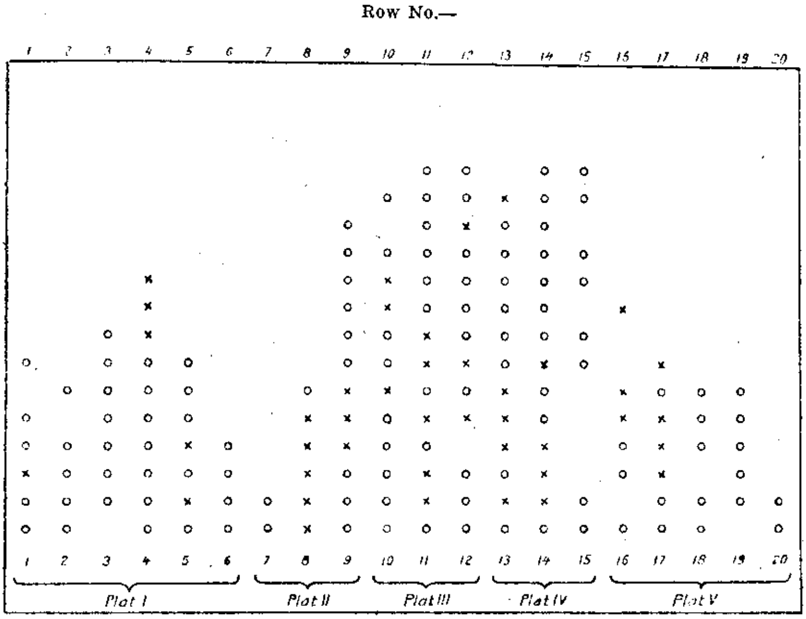

FIG. 1. Orchard A, at Lamao, Bataan Province, Luzon, showing location of *Corticium* cases in October, 1917. Circles show location of unaffected trees. Crosses show location of affected trees.

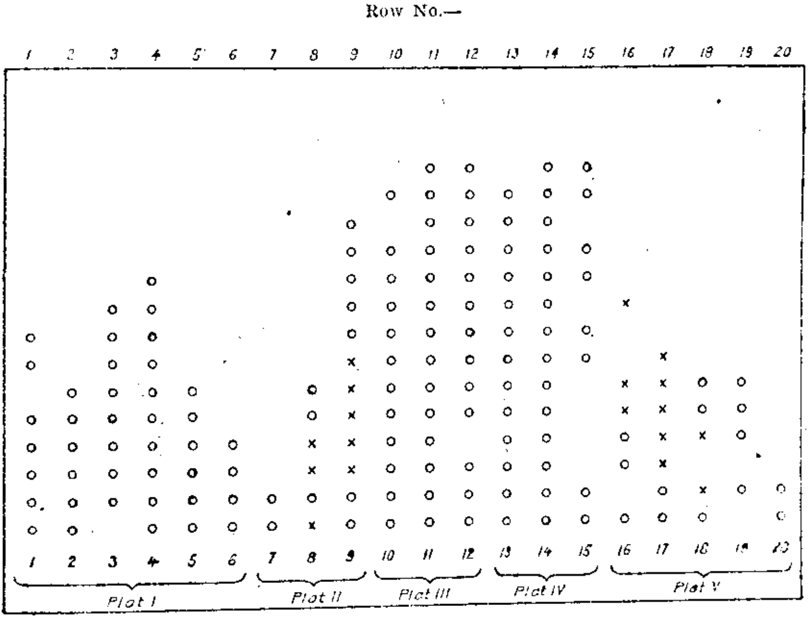

FIG. 1. Orchard A, at Lamao, Bataan Province, Luzon, showing location of *Corticium* cases in August, 1918. Circles show location of unaffected trees. Crosses show location of affected trees.

the affected places with tar. Although it does not seem reasonable to assume that such applications penetrate and kill the mycelium within the tissues, the report states that control is obtained in most cases. These results are in agreement with the observations made in the Philippines on the superficial application of fungicides; there, strangely enough, such applications have resulted in apparently complete control.

Although spraying is usually not practicable against pink disease on rubber, because of the size of the trees, it would seem to be the simplest method for the control of this disease on *Citrus*, since the application of fungicides may be combined with control methods against citrus canker, citrus scab, and, when lime sulphur is used, against scale insects. It seems probable that spray applications in connection with pruning would also prove an effective and simple control of the disease upon cacao, coffee, tea, and similar plants.

RECOMMENDATIONS

It is apparent that a control approaching almost complete eradication has been attained at Lamao. It seems probable that the fundamental procedure is the careful removal of affected limbs together with precautionary disinfection methods. However, it is also apparent that much can be accomplished by spraying as a preventive measure. Although copper sprays, such as Bordeaux and Burgundy mixtures, have proved successful against pink disease, they have the disadvantage of killing the fungus parasites of scale insects, thus bringing about a great increase in the latter. The use of copper sprays, therefore, is not recommended in the treatment of pink disease on *Citrus*, because of the great increase of scale insects following their repeated application. For this reason lime sulphur is suggested, not only because it is apparently as efficacious as are the copper sprays against pink disease, but also because it has been found of value against scale insects. Lime sulphur 1 to 40 is sufficiently strong, although it has been found that lime sulphur 1 to 35 will cause no injury to the foliage of citrus trees. A discussion of the preparation of lime sulphur is given by Waite.[24]

The time for spray applications varies with the season. For a normal season in central Luzon an application about May 15, another June 15, and another July 15, should be sufficient; that is, at the beginning of the wet season, in the middle of the wet season, and toward its close. Should heavy rains and high humidity continue into August, another application in August would be advisable.

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[24] Waite, M. B., Fungicides, and their use in preventing disease of plants, *Bull. U. S. Dept. Agr.* 243 (1916).

It should be emphasized that moisture conditions vary greatly in different parts of the Philippines and that the time for spraying in different islands would also vary with the periods and degree of rainfall in the various localities.

It seems probable that similar control methods would prove of value against pink disease of tea, coffee, cacao, and other crop plants, although we have no experimental data on which to make a definite statement.

DISCUSSION OF THE SERIOUSNESS OF PINK DISEASE AND ITS OCCURRENCE IN THE PHILIPPINES

Pink disease when uncontrolled causes serious injuries and often results in the death of entire trees and consequent economic losses. Plates V, VI, and VII show some of the effects of the disease. At present it is apparently not widely distributed in the Philippine Islands; but, should control measures not be adopted, conditions in regard to this disease may be expected to develop similar to those existing in the Federated Malay States, where the disease had gained a foothold before its seriousness was appreciated. Pest gangs are now maintained upon many rubber estates there for the purpose of disinfecting *Corticium* wounds and treating other diseases. It is to be hoped that Filipino planters will profit by experience in other countries, especially as the activities of the disease on *Citrus* trees at Lamao indicate what may take place if no control methods are attempted. In an area of not more than 12 hectares (30 acres) at least three hundred cases of *Corticium* have been observed. It should be remembered also that pink disease is a killing disease rather than one that merely takes its percentage from the financial returns by lowering the efficiency of the tree.

Although control by spraying and pruning is simple and comparatively inexpensive on *Citrus*, because of its localized occurrence at present, it seems possible to go further and entirely eradicate this disease from the Philippine Islands. Such eradication being effected, enforcement of adequate quarantine regulations should prevent the reintroduction of *Corticium salmonicolor* B. & Br., and the continual fight against the disease and the consequent expenditure of money would not need to be repeated from year to year. That eradication is possible is shown by the results being obtained in the United States against citrus canker, a disease which is much more infectious and difficult to control. It is particularly desirable to take steps to eradicate this disease before it has spread into privately owned Filipino holdings, where eradication would be extremely difficult.

Another question perhaps worthy of consideration is the possibility of the introduction of the disease into the southern United States. Von Speschnew[25] has reported *Corticium salmonicolor* B. & Br. on tea in the Caucasus. More recently Sawada has reported the fungus in Formosa at a latitude much the same as that of lower Florida, and the climate of southern Florida would seem quite as tropical as is that of Formosa. Rant, moreover, has reported *Corticium* on cinchona in Java, at an elevation of 2,000 meters, at which altitude in the Tropics the temperature is very considerably lowered.

Therefore, there seems to be the possibility that this fungus would develop readily in southern Florida or even in the other Gulf States, where the summer months are warm, wet, and humid. The necessity of preventing the introduction of this disease into the southern United States by quarantine measures is emphasized even more strongly by the report of *Corticium salmonicolor* B. & Br. in Porto Rico.

SUMMARY

1. Pink disease caused by *Corticium salmonicolor* B. & Br. has been observed in the Philippines upon various species and varieties of *Citrus*. It has been found in only three localities and is apparently a recent introduction.
2. Review of the literature shows it to be widely distributed throughout the oriental Tropics and that it causes serious economic losses in various countries on a number of hosts.
3. The appearance of the disease on *Citrus* is described. Control experiments are discussed which show that removal of affected limbs, accompanied by spraying, results in an effective control approaching entire eradication. The methods are simple and comparatively inexpensive. The results indicate that the commonly used fungicides are equally effective; however, lime sulphur is recommended since it is of value against scale

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[25] Von Speschnew, N. N., Die Pilzparasiten des Theestrauches. Berlin (1907).

insects also. The control methods employed against pink disease combine well in a general spraying plan against other citrus disease.

4. It is probable that these control methods may be equally effective against pink disease on cacao, coffee, tea, and similar plants.

5. Since pink disease is as yet localized, we recommend that strong measures be taken for its complete eradication. Effective measures taken now would probably save the Philippine Islands from considerable financial loss in the future.

6. The possibility of this disease becoming established in the Gulf States of the United States is indicated.

ILLUSTRATIONS

[From photographs by Lee and by Cortes.]

PLATE I

FIG. 1. The sterile mycelium stage and pustule stage of *Corticium salmonicolor* B. & Br. The white advancing mycelium is also shown. Natural size.

2. *Corticium salmonicolor* in culture upon potato plug; in culture and occurring naturally the color is the most characteristic feature of this fungus in its sterile stages. Natural size.

PLATE II

FIG. 1. Early stage of pink disease on *Citrus*, showing gumming and first appearance of pustules. Natural size.

2. Showing the color of the sterile mycelium and advancing hyphae of *Corticium salmonicolor*. Natural size.
3. *Necator* stage of the fungus on *Citrus* twigs. Natural size.
4. Another specimen, showing *Necator* stage of the fungus on *Citrus* twigs. Natural size.

PLATE III

Showing early appearance of *Corticium salmonicolor* on *Citrus;* the pustule stage. Natural size.

PLATE IV

FIG. 1. Early stages of surface mycelium of *Corticium salmonicolor* on *Citrus* sp. Natural size.

2. A specimen similar to that of fig. 1; also showing gumming. Natural size.

PLATE V

Effect of pink disease on tree of *Citrus maxima* in nursery row.

PLATE VI

FIG. 1. Showing effect of pink disease on tree of Washington navel (*Citrus sinensis*).

2. The pink disease as it spreads up and down branches; in this case on Washington navel tree.

PLATE VII

FIG. 1. Tree of *Citrus sinensis* killed by pink disease. Lamao, Bataan, P. I. August 16, 1918.

2. Another view of orange tree killed by pink disease. Lamao, Bataan, P. I.

TEXT FIGURES

FIG. 1. Orchard A, Lamao, showing location of *Corticium* cases in October, 1917.

2. Orchard A, Lamao, showing location of *Corticium* cases in August, 1918.

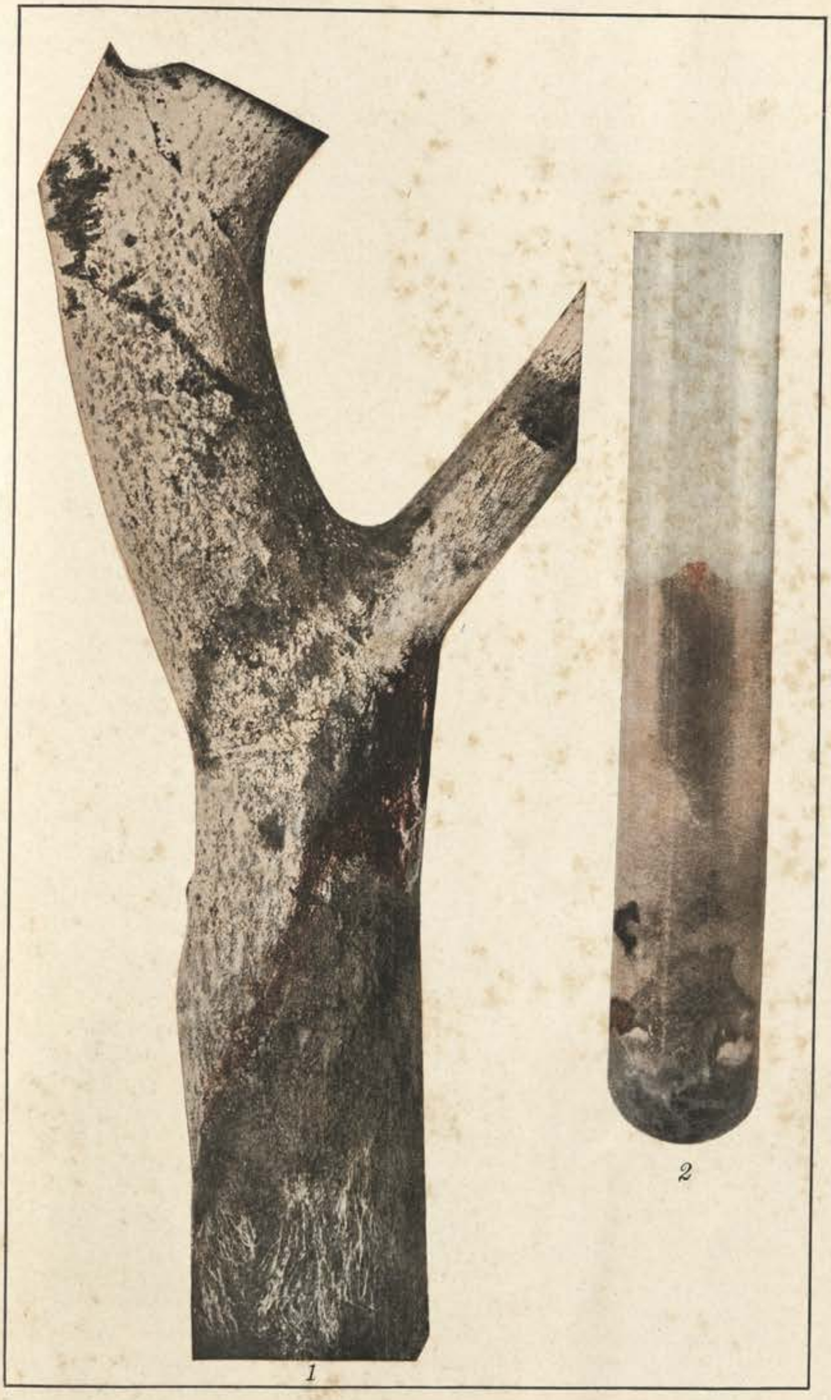

PLATE I. CORTICIUM SALMONICOLOR B. & BR.

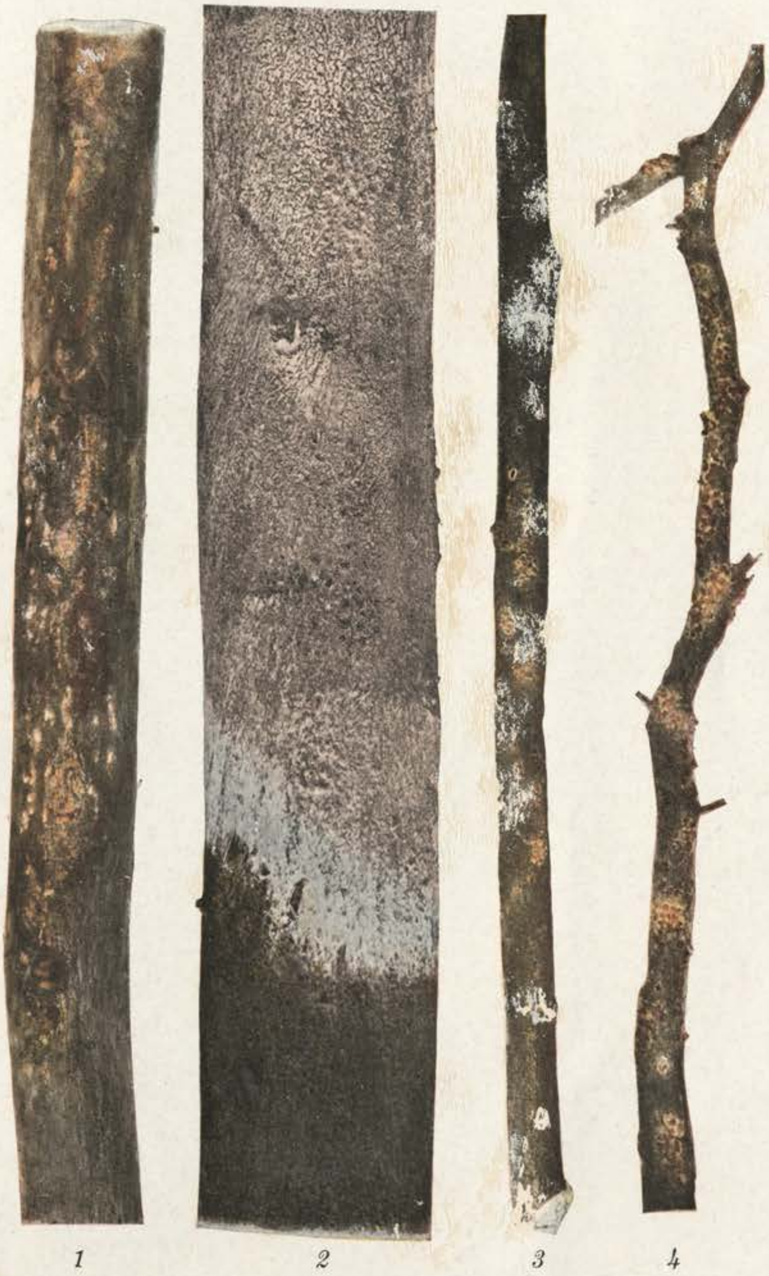

PLATE II. PINK DISEASE ON CITRUS.

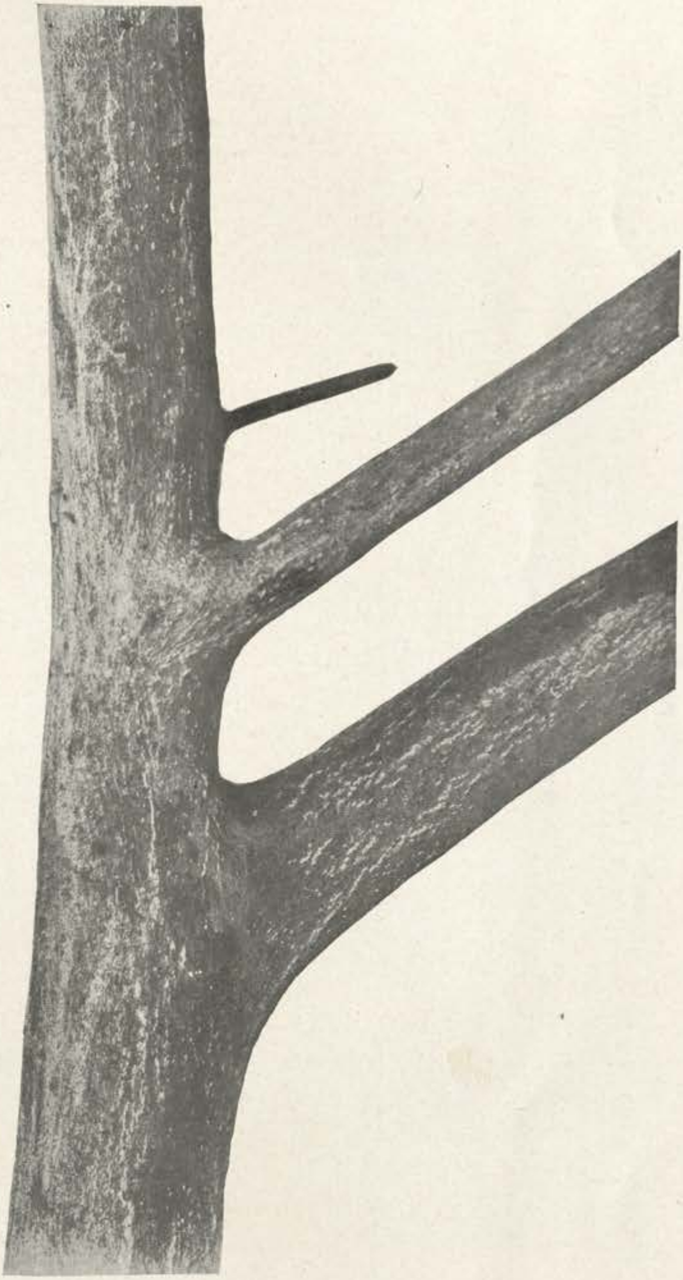

PLATE III. CORTICIUM SALMONICOLOR ON CITRUS; THE PUSTULE STAGE. NATURAL SIZE.

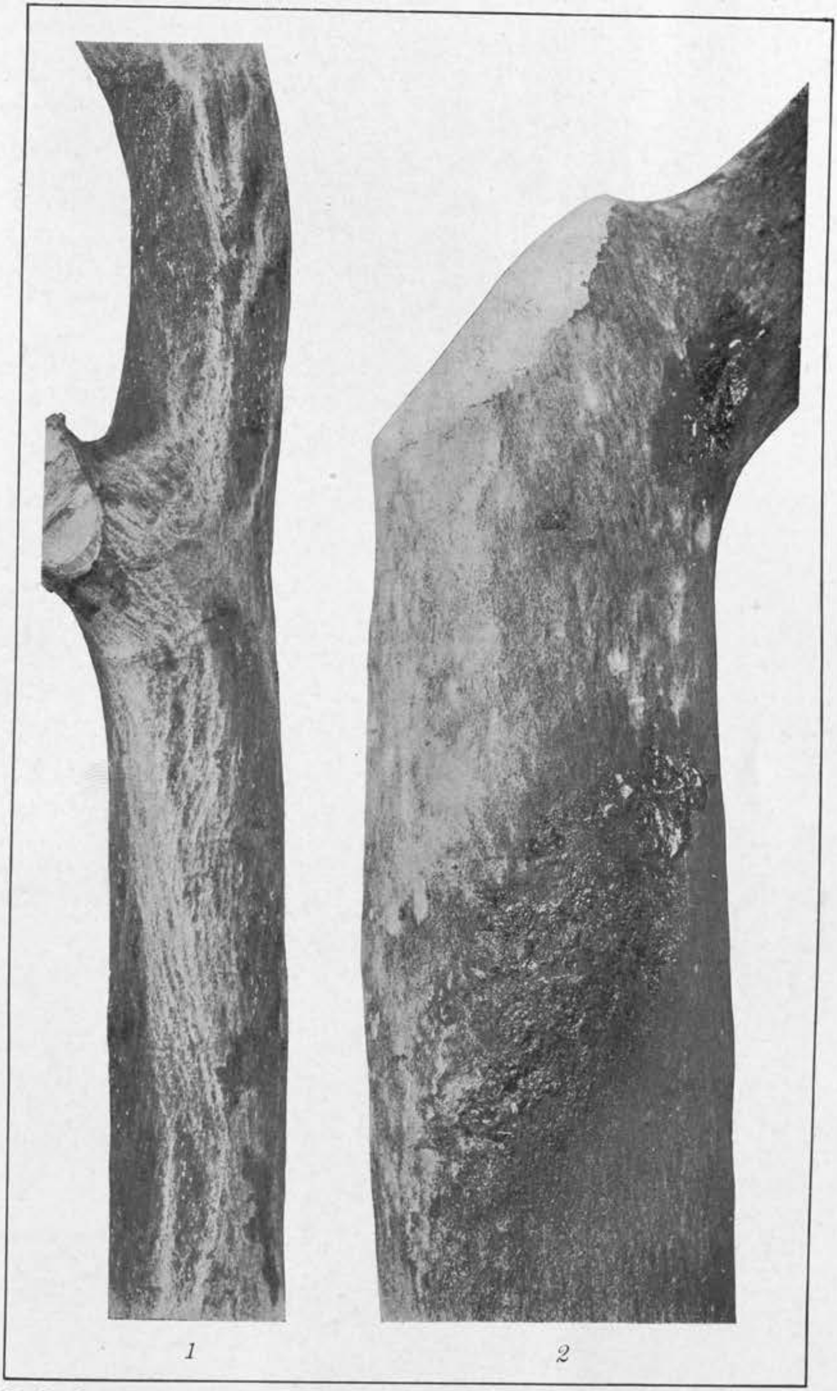

Fig. 1. Early stages of surface mycelium of Corticium salmonicolor on Citrus sp. 2. Similar to fig. 1; also showing gumming. Both figures natural size.

PLATE IV.

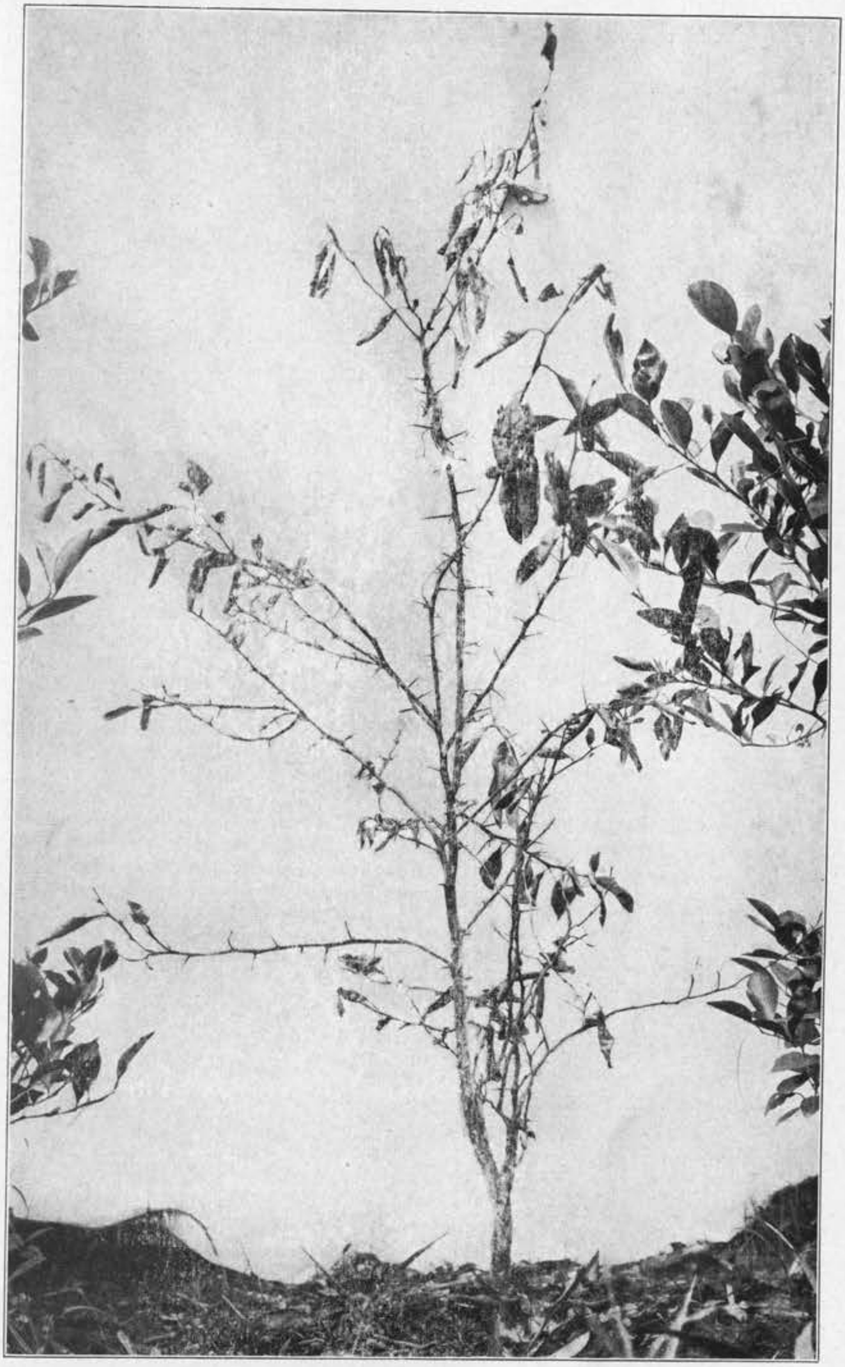

PLATE V. EFFECT OF PINK DISEASE ON TREE OF CITRUS MAXIMA IN NURSERY ROW.

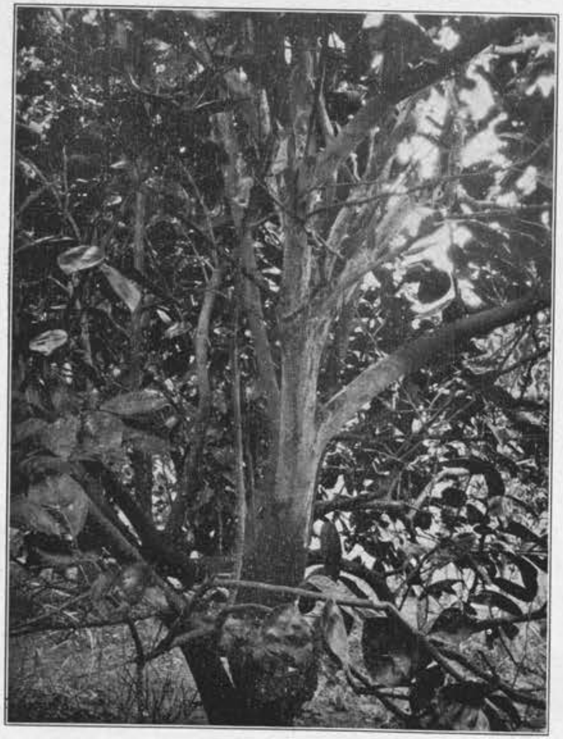

Fig. 1. Pink disease.

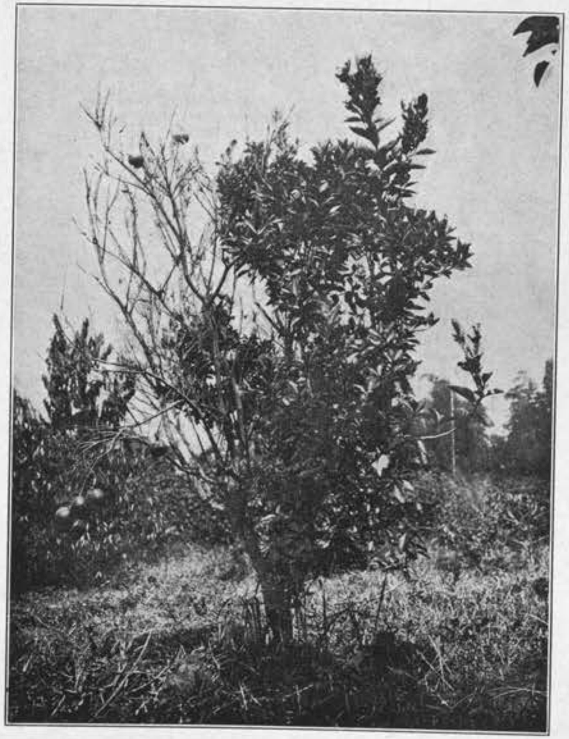

Fig. 2. Pink disease.

PLATE VI.

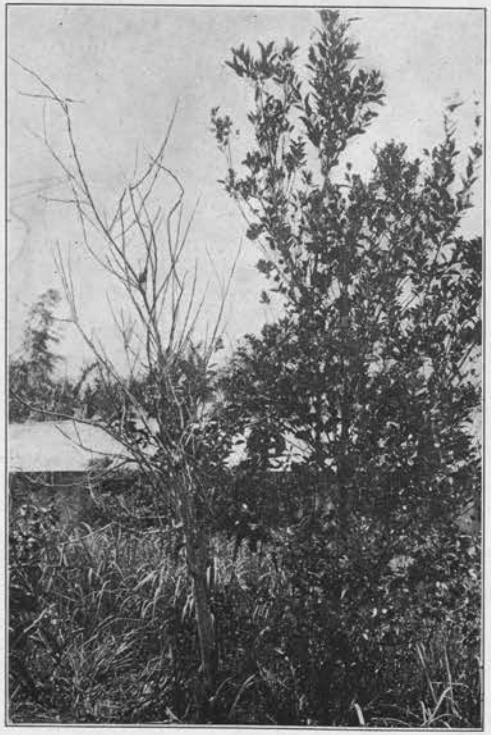

Fig. 1. A citrus tree killed by pink disease.

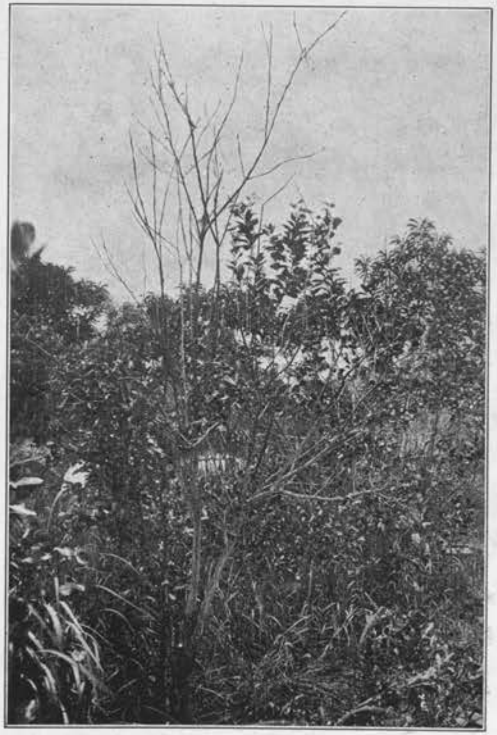

Fig. 2. An orange tree killed by pink disease.

PLATE VII.

ERRATA

Page 1, line 21, for *Xanthorriza* read *Xanthorrhiza.*

Page 3, line 11 from the bottom, *for* SIMEA *read* SIAMEA.

Page 50, column 2, line 1, Table XXIII, *for* Intramuscular *read* Intravenous.

Page 299, column 2, line 15 from the bottom for *Meyerianus* read *meyenianus.*

Page 300, column 1, lines 25, 26, and 28, for *siphonosphathus* read *siphonospathus.*

Page 300, column 2, lines 1, 3, and 5, for *siphonosphathus* read *siphonospathus.*

Page 326, last line, for *cagayensis* read *cagayanensis.*

Page 328, lines 5 and 6 from bottom, for *cagayensis* read *cagayanensis.*

Page 338, line 7 from bottom, *for* **FRUCTICANS** *read* **FRUTICANS.**

Page 347, line 10 from the bottom, for *siphonosphathus* read *siphonospathus.*

Page 354, line 25, *for* **SIPHONOSPHATHUS** *read* **SIPHONOSPATHUS.**

Page 396, line 7 from the bottom, for *zamboanguensis* read *zamboangensis.*

Page 437, line 2 from the bottom, for *machranta* read *macrantha.*

INDEX

[New generic and specific names and new combinations are printed in clarendon; synonyms and names of species incidentally mentioned in the text are printed in *italic*.]

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